AIC
LISBOA
2018

colour & human comfort

Proceedings of the International Colour Association (AIC) Conference 2018

Lisbon, PORTUGAL
25 – 29 September 2018

Sponsored by Associação Portuguesa da Cor (APC)
Published by International Colour Association (AIC)

associação portuguesa da cor

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This publication includes keynote, oral and poster papers presented in the International Colour Association (AIC) Conference 2018. The theme of the conference was Colour and Human Comfort. The conference, organised by the Associação Portuguesa da Cor (APC), was held in Lisbon, Portugal on 25-29 September 2018. More information in: www.aic2018.org.

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Australia
www.aic-colour.org

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TABLE OF CONTENTS:

AIC, International Colour Association

AIC Executive Committee

President: Tien-Rein Lee | **Past President**: Nick Harkness | **Vice President**: Vien Cheung | **Secretary Treasurer**: Leslie Harrington | **Committee Members**: Maurizio Rossi, Paula Csillag, Takahiko Horiuchi, Ralf Weber.

Member Countries

Argentina: Grupo Argentino del Colour | **Australia**: Colour Society of Australia | **Belgium**: Interdisciplinary Colour Association – Belgium **Brazil**: Associação Pró-Cor do Brasil | **Bulgaria**: Colour Group – Bulgaria | **Canada**: Colour Research Society of Canada | **Chile**: Asociación Chilena del Color | **China**: Color Association of China | **Croatia**: Hrvatska Udruga Za Boje | **Finland**: Suomen Väriyhdistys Svy Ry | **France**: Centre Français de la Couleur | **Germany**: Deutscher Verband Farbe | **Great Britain**: The Colour Group (Great Britain) | **Hungary**: Hungarian National Colour Committee | **Ital**y: Gruppo del Colore - Associazione Italiana Colore | **Japan**: Color Science Association of Japan | **Korea**: Korean Society of Color Studies | **Mexico**: Asociación Mexicana de Investigadores del Color | **Norway**: Forum Farge | **Portugal**: Associação Portuguesa da Cor | **Slovenia**: Slovensko Zdruzenje za Barve | **Spain**: Comité Español del Color | **Sweden**: Stiftelsen Svenskt Färgcentrum | **Switzerland**: Pro/Colore | **Taiwan**: Color Association of Taiwan | **Thailand**: The Color Group of Thailand | **The Netherlands**: Stichting Kleurenvisie: Het Nederlands Platform voor Kleur | **United States of America**: Inter-Society Color Council.

AIC Associate Members

North America: International Association of Color Consultants/Designers | United States of America: Color Marketing Group.

AIC Study Groups

Study Group on The Language of Colour (LC): Chair: Dimitris Mylonas (United Kingdom), Co-Chair: Galina Paramei (United Kingdom) | **Study Group on Colour Education (CE)**: Chair: Robert Hirschler (Hungary and Brazil) | **Study Group on Environmental Colour Design (ECD)**: Chair: Verena M. Schindler (Switzerland), Co-Chair: Yulia A. Griber (Russia | **Study Group on Arts and Design (AD)**: Chair: Prof. Dr. Maria João Durão (Portugal) | **Study Group on Colour Vision and Psychophysics (CVP)**: Chair: Katsunori Okajima (Japan), Secretary: Manuel Melgosa (Spain).

AIC President's Message: Tien-Rein Lee

Dear members of the AIC International Colour Association,

On the occasion of the AIC Interim Meeting in Lisbon, Portugal, the global colour community is once again getting together to celebrate the astonishing abundance of colour research and development and the substantial significance it has – in its contribution to the spheres of science, design, and arts, and to societies worldwide.

It is a great honour for me to very warmly welcome all participants and attendees from our global colour community to enthusiastically engage and indulge in a most colourful exchange of ideas throughout this event. Under the well-chosen topic of "Colour & Human Comfort", you are cordially invited to share and discuss your fields of expertise with a multidisciplinary group of specialists from scientific, technological and artistic domains. As the conference theme aims to relate the human being with comfort through the transdisciplinary knowledge of colour, it recognizes the important impact colour may have for the human well-being, and the roles colour can play in every person's daily life experiences.

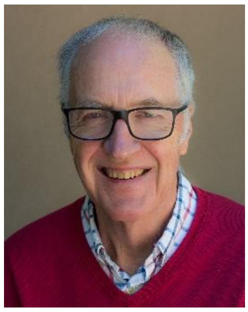
Now when the iconic crow of St. Vincent is going to spread its wings over the colourful city of Lisbon, I am sure we will all enjoy a very fascinating and inspiring conference with a program including all main topics of colour interest and R&D: ranging from Colour in the Built Environment, Colourimetry, and Colour in Arts and Design, over Colour and Lighting, Colour and Culture, Colour and Health, and Colour and Physiology, to Colour and Psychology, Digital Colour, and Colour and Landscape. Experts from many places all over the world are expected to take part in shaping this event to become another milestone in the history of the AIC International Colour Association.

Therefore, I would like to express my utmost gratitude towards the Organizing Committee and the Scientific Committee of this AIC Interim Meeting, especially to the Committee Chairs held by Prof. Dr. Margarida Gamito and Prof. Dr. Maria João Durão, the Co-Chairs held by Prof. Dr. Fernando Moreira da Silva, Prof. Dr. João Pernão and Architect MSc Zélia Simões, but as much to all presenters and the nearly 70 reviewers and all other responsible people involved, for their excellent work in preparing this remarkable conference program, and for turning the event into a colourful, radiating stage of expertise.

Wishing you a most exciting and inspiring time at the "Colour & Human Comfort" AIC Interim Meeting 2018 in Lisbon!

Prof. Dr. Tien-Rein Lee
AIC President

AIC Past President's Message: Nick Harkness



Dear Friends

I am delighted to have been invited by APCOR to write a welcome to you all to AIC 2018 in the dynamic city of Lisbon. I first visited Portugal more than forty years ago mostly in north and the area around Oporto. Fond memories of great lobsters, sardines and superb wines from the Douro valley and of course the wonderful friendly Portuguese.

Portugal was our country of choice for our last holiday in Europe before my wife and I left England in 1978 for a new adventure in Australia.

I was not invited to reminisce but to let you know what has been achieved by the AIC over the last two years which is truly remarkable. For me the four most important initiatives are the establishment of the new AIC Student Awards which will be managed by the JAIC editorial team, Stephen Westland and Vien Cheung (Vice President of AIC). The new AIC Study Group on Arts and Design which is the brain child of Maria João Durão, a very active member of the Executive Committee of the AIC, setting the wheels in motion for a much more interactive AIC website which is being managed very successfully by Leslie Harrington (Secretary/Treasurer of AIC). Log on if you have not already and experience the ease of navigation around the website. Last but not least, our application for ISSN accreditation for the JAIC and Proceedings from AIC meetings which has been the result of hard work by Vien Cheung. All these initiatives will greatly enhance the prestige of AIC and its academic excellence.

AIC 2018 is the launch pad for these initiatives, please give them your full support. The first Student Awards have been greeted with an amazing response with approximately, 30 submissions from fourteen countries. There will be a special edition of the JAIC which will feature the six best papers. If this momentum is maintained the AIC has the resources to offer more awards which could be spread across a range of disciplines.

To you all and especially my friends at APCOR have a fabulously colourful time in Lisbon.

Best regards,

Nick Harkness

Immediate Past President AIC

Associação Portuguesa da Cor President's Message: Margarida Gamito

Dear Friends,

It is a great pleasure to the Portuguese Colour Association to host the 2018 AIC Interim Meeting, even more because it is the first time that the AIC comes to Portugal, and more specifically to Lisbon.

Lisbon, besides being the capital of Portugal, is the westernmost capital city in continental Europe and the only one along the Atlantic coast. It is also one of the oldest cities of the world, and the oldest in Western Europe, predating by centuries other modern European capitals such as London, Paris and Rome. The omnipresence of the Tagus river, adding to the numerous hills and vegetation, provides the city with a high-quality light that enhances the colour of its buildings.

The Symbol for AIC Lisboa 2018 is a crow, which represents the guardian of Lisbon and is always present on the city shield. An ancient legend which connects the crow to St. Vincent, the patron saint of Lisbon, says that these birds had escorted the body of Saint Vincent since his death till his translation to Lisbon, on the 12th century. Also present on the Conference logo are coloured squares that represents some of the determinant elements of Lisbon's historic identity, namely its glazed tiles and cobbled stones. Simultaneously, these squares refer to the building blocks of light and colour, so characteristic of Lisbon.

The choice of the main topic – Colour and Human Comfort – embraces a very large variety of themes, because Colour is always present in all aspects of human life.

This event of great scientific relevance shall bring together an interdisciplinary group of specialists from all over the world, who use colour in both scientific research and professionally, addressing a key issue in the relationship of colour to the society: human comfort. So, this Conference has constituted a great challenge for our Association, as it reunites participants from more than thirty countries, and over than a hundred and thirty papers.

As President of the Portuguese Colour Association, I am very happy to welcome all of you to Lisbon and, especially to this colourful event, wishing that AIC Lisboa 2018 will bring more Colour into everybody's life.

Margarida Gamito
Portuguese Colour Association President

AIC LISBOA 2018 **Chairs' Preface**

We are happy to welcome you to the International Colour Association Interim Meeting 'Colour and Human Comfort' at *Fundação Calouste Gulbenkian*, Lisbon, Portugal, Sep. 26-28, 2018. The *AIC Lisboa 2018* is hosted by the Associação Portuguesa da Cor-APC bringing to Lisbon a multidisciplinary group of experts and specialists who use colour and light within a broad range of domains with a focus on human comfort.

During the conference days, colour will be discussed as a fundamental component for the achievement of comfort and wellbeing in our lives. The relevance of colour towards the fulfilment of comfort is evident in multiple topics presented at oral and poster sessions: Healthcare facilities and Medicine; Psychology: Preferences, Senses and Perception; Colour and Lighting: Human Comfort; Lighting Technologies; Arts and Design: Fashion, Communication and Product design, Painting and Drawing; Built Environment; Urban and Rural environments; Architecture and Interior Design; Landscape; Colour and Culture: Religion, Philosophy and Transcultural Colour; Education, Lexicology and Poetry; Heritage; Digital Colour; Colorimetry and Audiovisuals.

A total of 261 abstracts were submitted and evaluated by 65 international reviewers. The final programme integrates 77 oral presentations and 58 posters, to be presented to an audience comprised of 220 registered international colour experts from 41 countries. As part of the Conference Programme, AIC Study Group meetings run in parallel sessions and in order to encourage excellency of research, three participants are distinguished with 'Poster Awards'. Furthermore, we are proud to present five keynote lectures by Jose Luis Caivano, Tomás Taveira, Luísa Arruda, Byron Mikellides, and João Brehm.

Pre-conference activities include four workshops and a Welcome Reception at Lisbon University Faculty of Architecture garden that joined together dinner and singing by Portuguese Coral Group – MUSAICO. In addition, the Gala Dinner is on board the *Confeitaria Nacional* boat, along the Tagus river, an unusual perspective to appreciate Lisbon by night and at the sound of a *Fado* singer and guitar players.

We also offer two post-conference optional excursions; either a tour in the village of Sintra with visits to the Royal Palace of Sintra – *Palácio da Vila* – and *Monserrate* Palace and Gardens, or an excursion through Old Lisbon with a visit to the Tiles Museum – *Museu do Azulejo*.

At the AIC2018 new initiatives are launched: AIC Student Awards distinguishing six students, and a new AIC Study Group on Arts and Design. Also, it is the first time that AIC Proceedings are published by the International Colour Association under a unique serial publication ISSN/eISSN as continuing resource.

We are extremely thankful to all members of the AIC 2018 Executive Committee and International Scientific Committee for their enthusiastic commitment and contribution to the organization of this scientific event. We also thank collaborators and sponsors that added to the quality of this event.

We hope you enjoy the AIC 2018 Interim Meeting programme, the chosen venue and its extraordinary qualities- architecture, garden design and art collection-, the uniqueness of Lisbon light, and potential encounter and exploration of new paths of colour phenomena!

Margarida Gamito and Maria João Durão
AIC Lisboa 2018 Chairs

AIC LISBOA 2018 Committees

AIC Lisbon 2018 Honour Committee

President: His Excellency the President of the Republic, Professor Dr. Marcelo Rebelo de Sousa.

Members: His Excellency the Minister of Culture, Dr. Luís Filipe Castro Mendes | His Excellency the Minister of Science, Technology and Higher Education, Professor Dr. Manuel Heitor | His Excellency the Mayor of Lisbon, Dr. Fernando Medina Maciel Almeida Correia | H. E. the President of the Foundation for Science and Technology, Dr. Paulo Ferrão | H. E. the President of the Calouste Gulbenkian Foundation Board of Trustees, Dr. Isabel Mota | H. E. the Rector of the University of Lisbon, Professor Dr. António Manuel da Cruz Serra | S. E. the President of Lisbon School of Architecture, Professor Dr. João Cottinelli Telmo Pardal Monteiro | S. E. the President of the Board of Administration of CIN, Eng. João Serrenho.

AIC Lisbon 2018 Organizing Committee

Chairs: Margarida Gamito and Maria João Durão.

AIC Lisbon 2018 Scientific Committee

Presidency:
Chair: Maria João Durão |**Co-chairs**: João Pernão, Zélia Simões | **Communication Associates**: Filipa Santos and Helena Soares | **Workshops organization**: João Pernão.

Reviewers:
Alessandra Cirafici (ITA), UNINA | Ana Guerreiro (POR), FA - ULISBOA / CIAUD | Andrew Stockman (GBR), UCL - INSTITUTE OF OPHTHALMOLOGY | Annamaria di Cara (AUS), DESIGN CENTRE ENMORE - SYDNEY TAFE | Berit Bergstrom (SWE), SWEDISH COLOUR CENTRE FOUNDATION - NCS COLOUR AB | Carl Jennings (USA), UNIVERSITY OF HAWAII – KAPIOLANI | Carlos Alho (POR), FA - ULISBOA / CIAUD | Cristina Caramelo Gomes (POR), ULL / CITAD | Cristina Figueiredo (POR), FA - ULISBOA / CIAUD | Cristina Pinheiro (POR), IADE - UE / UNIDCOM | Dimitris Mylonas (GBR), UCL / AIC - STUDY GROUP ON THE LANGUAGE OF COLOUR (LC) | Doreen Balabanoff (CAN), OCAD UNIVERSITY | Dulce Loução (POR), FA - ULISBOA / CIAUD | Fernando Moreira da Silva (POR), FA - ULISBOA / CIAUD | Francesca Valan (ITA), IED / SPD | Gabriela Nirino (ARG), FADU - UBA / UTN – FRBA | Georgina Ortiz Hernández (MEX), FACULTY OF PSYCHOLOGY - UNAM / AMEXINC | Gianni Montagna (POR), FA - ULISBOA / CIAUD | Harald Arnkil (FIN), AALTO UNIVERSITY SCHOOL OF ART, ARCHITECTURE AND DESIGN | Ingrid Calvo Ivanovic (CHI), UCHILE | Javier Romero Mora (ESP), UNIVERSITY OF GRANADA | João Carlos César (BRA), FAU – USP | João Pernão (POR), FA - ULISBOA / CIAUD | Joaquim Santos (POR), ULL / CITAD | John Hutchings (GBR), UNIVERSITY OF LEEDS | Jorge Souto (POR), ESCS / ICML | José Aguiar (POR), FA - ULISBOA / CIAUD | Jose Luis Caivano (ARG), FADU - UBA / CONICET | Katsunori Okajima (JPN), YNU / AIC - STUDY GROUP ON COLOUR VISION AND PSYCHOPHYSICS (CVP) | Leonor Ferrão (POR), FA - ULISBOA / CIAUD | Lindsay MacDonald (GBR), UCL | Luisa

Costa (POR), ISMT / CIAUD | Mahshid Baniani (JPN), UNIVERSITY OF TSUKUBA | Manuel Melgosa Latorre (ESP), UNIVERSITY OF GRANADA | Manuel Pais Clemente (POR), APCOR / EUROPEAN MEDICAL ASSOCIATION | Margarida Gamito (POR), FA - ULISBOA / CIAUD | Maria João Durâo (POR), FA - ULISBOA / CIAUD | Mário Kong (POR), FA - ULISBOA / CIAUD | Maurizio Rossi (ITA), POLYTECHNIC - UNIVERSITY OF MILAN | Miguel Sanches (POR), IPT / CIAUD | Ming Ronnier Luo (GBR), UNIVERSITY OF LEEDS | Natacha Antão Moutinho (POR), EA – UMINHO | Nick Harkness (AUS), NICK HARKNESS PTY LTD | Nuno Alão (POR), FA - ULISBOA / CIAUD | Patrick Callet (FRA), MICS - UNIVERSITY OF PARIS-SACLAY / CAOR - PSL RESEARCH UNIVERSITY | Paula Csillag (BRA), ESPM - SP / PROCOR | Paul Green-Armytage (AUS), CURTIN UNIVERSITY | Pedro George (POR), FA - ULISBOA / CIAUD | Ralf Weber (GER), TU DRESDEN | Robert Hirschler (HUN), AIC - STUDY GROUP ON COLOUR EDUCATION (CE) | Rodrigo Ramírez (MEX), UAM AZCAPOTZALCO | Rui Barreiros Duarte (POR), FA - ULISBOA / CIAUD | Saadet Akbay (TUR), ÇANKAYA UNIVERSITY - FA / CIAUD | Sarah Frances Dias (POR), FA - ULISBOA / CIAUD | Sérgio Nascimento (POR), DF – UMINHO | Simone Maffei Simacek (BRA), UNISO | Stephen Westland (GBR), UNIVERSITY OF LEEDS | Takahiko Horiuchi (JPN), CHIBA – U | Tien-Rein Lee (TPE), CCU | Valérie Bonnardel (GBR), UNIVERSITY OF WINCHESTER | Valter Cardim (POR), IADE - UE / UNIDCOM | Verena M. Schindler (SWZ), AIC - STUDY GROUP ON ENVIRONMENTAL COLOUR DESIGN (ECD) | Verónica Conte (POR), FA - ULISBOA / CIAUD | Victor Lopes dos Santos (POR), FA - ULISBOA / CIAUD | Vien Cheung (GBR), UNIVERSITY OF LEEDSC.

AIC Lisbon 2018 Executive Committee

Presidency:
Chair: Margarida Gamito | **Co-chair**: Fernando Moreira da Silva

Sub-committees:
Financial Control and Management: Joana Sousa, Aldina Martins, Miguel Aboim Borges | **Communication and Graphics**: Cristina Pinheiro, Filipa Nogueira Pires, Luisa Costa, Miguel Sanches, Miguel Rafael | **Sponsorship, Patronage and Media Partners**: João Pernão, Luísa Martinez | **Equipment, Services and External Partners (Travel Agencies)**: Cristina Caramelo Gomes, Helena Pereira | **Organization of exhibition space** (posters): Manuela Soares | **Website / Facebook**: Filipa Nogueira Pires, Irina Costa, Simone Maffei Simacek

AIC LISBOA 2018 Conference theme:

Colour and Human Comfort

This theme aims to relate the human being with comfort through the transdisciplinary knowledge of Colour.

Wellbeing is the fundamental condition to be achieved in everyone's life, and colour could play a tremendous role towards that fulfilment, from the clothes we choose every morning to the house we live in, our workspace, the environment that surrounds us, the objects we love, and so on.

But we know that there are many places, objects and environments that are not comfortable. In some cases, the reason is simple — lack of knowledge — in others, it cloud be the desire to impose certain aesthetic tendencies.

Conference topics:

Colour in the Built Environment: Colour in Architecture | Colour in Urban Space | Colour in Rural Space | Interior Design | Stage Design | Museography.

Colourimetry: Colour Measuring | Colour Analysis | Technologies | Photometry | Methods | Theories and Instrumentations.

Colour in Arts and Design: Painting | Sculpture | Drawing; Theatre | Cinema | Dance | Music | Fashion Design | Communication Design | Product Design | Packaging Design | Marketing | Ergonomics | Sustainability.

Colour and Lighting: Light and Human Comfort | Light in Human Environments | Lighting Design | Lighting Technologies.

Colour and Culture: Colour in Heritage | Colour and Education | Transcultural Colour | Colour Aesthetics | Colour History | Sacred and Religious Colours | Anthropology of Colour | Philosophy of Colour | Sociology | Colour and Foo |; Colour and Language | Lexicology.

Colour and Health: Colour and Wellbeing | Colour in Healthcare Facilities | Colour and Neuroscience | Colour-Coded Labelling (medication, instruments, etc) | Medicine; Aesthetic Medicine | Light, Health and Wellbeing.

Colour and Physiology: Colour and the Human Being | Colour Vision | Optics | Memory | Colour Therapy.

Colour and Psychology: Colour Preferences | Colour and the Senses | Colour Perception | Perceptual Illusions | Phenomenology of Colour.

Digital Colour: Digital Colour Science | Digital Technology | Photography | Colour Image | Television and Audio-visuals | Colour Image | Virtual Reality (VR) and Augmented Reality (AR) environments | 3D Printing | Image processing | Virtual Projects.

Colour and Landscape: Natural Harmony | Natural Aesthetics | Land Art | Landscape Design | Geography of Colour | Biogeography of Colour | Geology | Ecology.

Keynotes Speakers:

Luísa Capucho Arruda

Artist, Art history researcher, Professor at School of Fine Arts, Lisbon University, Associated to Academia Nacional de Belas Artes, Lisbon, Portugal

Artist, Art history researcher and Associated Professor at Lisbon University, Fine Arts Faculty where she was President of the Representative Assembly and President of the board of Direction. Teaches drawing and has been coordinator of the Museology and Museografy Master. Organized the Prints and Drawings cabinet for nineteenth and early twenty century works on paper related with academic teaching and initiated the Fine Arts Faculty Virtual Museum. Member of the CIEBA, centre for research, she is now coordinator of the Francisco de Holanda section, and Coordinator of the Fine Arts PhD, specialization at drawing studies. Member of the ARTIS, Art History Institute of the Letters Faculty, Lisbon University and Member of the ANBA, National Academy of Fine Arts. She is member of the scientific board of the ArteTeoria, Art and Theory magazine. Lecturer in Portugal and abroad (Cordoba University, Academia di Belli Arti di Milano e Academia di Belle Arti de Roma), she is author of books and papers, on Portuguese drawing both contemporary (Antonio Duarte, Lagoa Henriques e Paula Rego) and historical (Francisco de Holanda, Francisco Vieira de Matos, Francisco Vieira Portuense e Domingos Sequeira e Cirilo Wolkmar Machado). Researcher on gender studies (Paula Rego, Josefa de Óbidos e Joana do Salitre) Also specialist in Portuguese tiles studies (from XVI to contemporary works of art) and patrimony (Saint Anne Hospital, Parede and Alcoitão Hospital, Convent of Saint Paul the Eremite, Ossa Mountains, Lisbon Palace of the Queen female attendants), has published books, chapter of books, and papers. Organized several Colloquies on Portuguese art. Curate art exhibitions and exhibits her own works of art.

João Brehm

Painter and Cinematographer
Colour experiments in my imaginary universes

João Brehm was born in Lisbon in 1951. Visual artist and film maker, he began his visual arts activity in 1968. Over 50 Individual and group national and international exhibitions (XII, XIII and XIV International Drawing Prizes Joan Miró, Barcelona, 1973/74/75; Alternativa Zero, Lisbon, 1977, etc). Diploma in Painting from the School of Arts António Arroio (Portugal) (1965-1968). Diploma in Interior Architecture from Institute of Visual Arts, IADE (Portugal) (1969-71).

In 1972 João Brehm went into exile in Paris and Brussels where he carried on his activity in the arts, photography, film and journalism. He owns a Bachelor degree in Film and Television awarded by the Institut National Supérieur des Arts du Spectacle, INSAS (1973/76), Brussels. Scholarship from the Calouste Gulbenkian Foundation in 1976/77 and 1977/78. Returned to Portugal in 1977 where he produced and directed several movies, e.g. "Transparencies in Silver", "Fighting children" (TV series), that were broadcasted on television and in national and international festivals.

In 2005 João Brehm resumed his activity as a Painter. Interested in the cosmic universe, he develops an imaginary and poetic survey of the Universe in painting and other materials, experimenting Colour, Light, Space, Movement and Depth. Lately João Brehm has also been exploring a microcosmos approach and has engaged in experimental video besides other forms of artistic expression.

Representation in Art Collections
Museums, municipalities and other public and private entities in Portugal: Serralves Foundation (Oporto, Portugal), Mobil Collection (Lisbon), José Malhoa Museum (Caldas da Rainha), Carlos Reis Municipal Museum (Torres Novas), Secretary of State for Culture (Lisbon), collection of the Municipality of Lisbon.

Awards
1970: Acquisition award, Mobil Collection, National Society of Fine Arts, Lisbon.
1968: Award of Tourism Board of Costa do Sol, Estoril.
João Brehm has his work and interview in a documentary of 2013 for the National Archive of Moving Images of the Portuguese Cinematheque.

José Luis Caivano

Artist, Art history researcher, Professor at School of Fine Arts, Lisbon University, Associated to Academia Nacional de Belas Artes, Lisbon, Portugal

Jose Luis Caivano graduated from Buenos Aires University (Architect and PhD). Research fellow at the National Council for Research, Argentina, and professor at the School of Architecture of Buenos Aires University, where he leads the Research Program on Color and Visual Semiotics. He holds the highest category (level 1) in the national research system of Argentina. He has been research associate at the Center for Language and Semiotic Studies of Indiana University, USA. He was president of the International Association for Visual Semiotics, the Argentine Color Group, and the International Color Association, where he also chaired the Study Group on Environmental Color Design. Honorary member of the French association Ad Chroma, the Portuguese Color Association, and the Mexican Association of Color Researchers.

Caivano has participated in more than 100 congresses in 28 countries, delivering invited lecturer and courses in Argentina, Taiwan, Turkey, Finland, France, Italy, Spain, Brazil, Canada, Chile, Colombia, Peru, Mexico, and Uruguay. Author and editor of books, he has published more than 130 articles in books and journals such as Color Research and Application (USA), Die Farbe (Germany), Colour: Design & Creativity (UK), Optica Pura y Aplicada (Spain), Colore (Italy), Languages of Design (Netherlands), Leonardo (USA), Semiotica (Germany), Visio (Canada), Cruzeiro Semiotico (Portugal), DeSignis (Spain), Symmetry: Art and Science (Hungary), and others. He was editor of the journal AREA, agenda of reflection on architecture, design and urbanism, and the monograph series Difusión, published by the School of Architecture of Buenos Aires University, and editor of the Proceedings of the Argentine Color Congresses. Currently he is associate editor of Color Research and Application, and member of the editorial committee of the Journal of the International Color Association, JAIC. He has been member of the editorial committee and the advisory board of the journals Visio, Web Architecture Magazine, and Languages of Design.

Fields of speciality: color theory, visual semiotics, morphology applied to architecture and design.

Byron Mikellides

Emeritus Professor at Oxford Brookes, the School of Architecture

Byron Mikellides is currently Emeritus Professor at the Oxford School of Architecture, Oxford Brookes University, where he has been teaching since 1968. He has published several books including Colour for Architecture (1976) and Colour for Architecture Today (2009) with Tom Porter, and Architecture for People (1980). He has also contributed to several books, scientific journals and papers over the years, and lectured in various countries particularly in USA and Scandinavia. He is also a reviewer of refereed journals and PhD examiner. Byron ran 3 compulsory modules in Architectural Psychology and Colour Psychology in years 1, 2, and 3 in the degree course and optional modules in the Diploma from 1968 till 2008. He was Admissions Tutor at the School for over 30 years, as well as being a member of various committees at the School including being the Secretary of the Doric Club representing the architectural Alumni. He is also a former member of Directors of IAPS (International Association of People Environment Studies), a committee member of the Colour Group of Great Britain and an Honorary member of the Portuguese Colour Association. He organised the Exhibition of Antonio Gaudi, in Oxford in 1983 and the 'Colours of Savannah' in Georgia, USA in 1996 for the Olympic Games. His most recent works include chapters in books such as Jane Wernick's Building Happiness (2010) on architectural psychology and Janet Best's Colour Design - Theory and Applications (2017).

Tomás Taveira

Architect, Urban Designer and Urban Planner

Tomás Cardoso Taveira, was born in Lisbon, graduated in Architecture from the Escola Superior de Belas Artes de Lisboa.
He is an Architect, Urban Designer and Urban Planner. His research encompasses such areas as the Theory of Urban Phenomena, Urban and Regional Planning, and the Theory of Taste based on the basis of the Theory of Architecture, Design and Fashion. He taught at ESBAL as assistant architect (5th year) and Theory and History of Architecture (4th year) in 1971, a situation that remained until February 1974 when he won the competition for Full Professor. In September 1977 he began his Fellowship at MIT fot the SPURS Program, a postgraduate course integrated in the MIT Ph.D. programs. Academically, at the 'Escola Superior de Belas Artes de Lisboa' / Lisbon Faculty of Architecture, Tomás Taveira was the creator of the 'Licenciaturas' (5year undergratuate courses) of Architecture of Design, of Fashion, of Urban and Territorial Planning, and of Urban Management that in the year of 1999 licensed the first professionals.

His theoretical papers are published in magazines and journals. His architectural work was published in 1991 by Academy Editions of London and St.Martin Press of New York. Again, in 1994, Academy Editions of London dedicated its 37th edition of Architectural Monographes, to his architectural work. In 2002 Artmedia Press of London published the book "Tomás Taveira" and in 2004, another book called "Taveira Sports Architecture".

Awards:
Prémio Valmor- (1982) attributed to the "Arco Iris" in Olaias Housing Complex.
Prémio José de Figueiredo (1982), by National Academy of Fine Arts, for the Study of Urban Renewal of the Martim Moniz Area.
Prémio Valmor and Prémio Municipal of Architecture (1993) - attributed to the Amoreiras Complex.
IOCK / IAKS AWARD 2005- GOLD AWARD - prize awarded to the Aveiro Municipal Stadium Project.

Full Papers by Topics and Alphabetic Order

AIC LISBOA 2018
colour & human comfort

Keynote Speakers

AIC LISBOA 2018
colour & human comfort

Colour in the historical hospitals of Cascais: *Hospital de Sant'Ana* in Parede and *Hospital Ortopédico* in Alcoitão

Luisa Arruda

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ABSTRACT
The discussion of colour at two historical hospitals in Cascais – *Hospital de Sant'Anna* in Parede (a sunlight and sea air sanatorium) and *Hospital de Alcoitão* (a rehabilitation medicine centre) – is, first and foremost, a reflection on new concepts of treatment and cure or rehabilitation, viewing the patient in human terms, and the implementation of these ideas in a space especially designed for the purpose. The physical form of the hospitals is an integral part of the philosophy underlying the new treatments. Human comfort and the humanist perspective place patients at the heart of the concerns of all decision-makers. The landscape or choice of site (the spirit of the place) is a determining factor for creating hospital architecture, responding to the new challenges of medical sciences. The quality of the spaces and solutions, the contributions of art and the distinctive presence of colour all decisively intervene in the process.

Keywords: *colour, architecture, hospital, human comfort, Cascais*

COLOUR IN THE HISTORICAL HOSPITALS OFCASCAIS: HOSPITAL DE SANT'ANA IN PAREDE AND HOSPITAL ORTOPÉDICO IN ALCOITÃO

The *Sanatório de Sant'Anna* (St. Anne's Sanatorium) in Parede, today called *Hospital de Santa Ana* (St. Anne's Hospital), is an imposing building that dominates the coastal landscape of Parede. It was designed by Rosendo Carvalheira and Álvaro Machado with the collaboration of Adolfo Marques da Silva, Manuel Joaquim Norte Júnior and António Couto Abreu. The architects brought into being the ambitious sunlight and sea air sanatorium project devised by eminent doctors Sousa Martins and José de Almeida to treat bone tuberculosis, among other illnesses rooted in malnutrition and hygiene problems, especially dedicated to children. Maria Amélia and Frederico

Biester generously sponsored the project, further driven by the Mayor of Cascais, Jaime Artur da Costa Pinto.

The building was erected on a plain base in the shape of a truncated pyramid, like the forts found on the coast. It is made of stone from the region and has a large façade facing south over the Estoril coast, with another to the north containing the chapel and the main entrance. When analysing the building, it is important to understand the foundations of the treatment philosophy based on exposure to sunlight and the benefits of sea air, that is at the heart of this type of sanatorium. The building system therefore encourages both sunlight and heat to come in and sea air to circulate, with open galleries and tiered roofs that also have openings, helping air to enter the towers in the roofs. These are connected to the building's basement, in a complex mechanical system that can be connected and disconnected as needed. The mechanised kitchen and laundries and electrical lighting demonstrated the use of pioneering technological developments. Both the newspapers of the time and contemporary architectural criticism followed the construction enthusiastically.

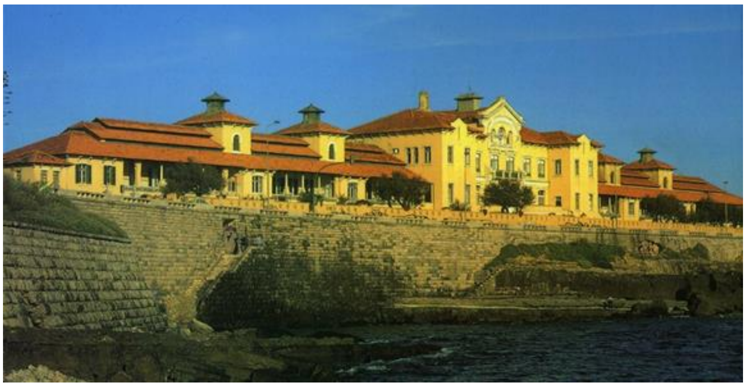

Fig. 1: Southeast façade of the Hospital de Sant'Ana

Built over a few years and opened in 1904, the sanatorium is a remarkable example of the Neo-Romanesque taste that, in Raul Lino's eyes, is the style that best represents Portuguese architecture. The colours of the materials are defined by the architectural design and have a decisive aesthetic function in perception of the blocks of the building, the colour of the limestone, the ochre red of the tiles, the ochre yellow painted masonry and the metal or pine green-painted wood features of the towers. Furthermore, the colours of the materials, again reflecting remarkable design, are extremely elegant and at the same time pleasurable when we come closer and can observe the details. On the south façade, there are the stone features of the main body, the columns of the colonnade, the spouts, the sculptures depicting mussels and other shells, the colours of the band of tiles decorating the colonnade also depicting

Fig. 2: Southeast façade sculptures

fish and algae against an ultramarine blue background. In the details of the south façade there is a desire for interaction and communication with the children staying at the sanatorium, materialized in the aesthetic creation of sea features of a type, scale and colour that encourage the playfulness of discovering and identifying things from the sea.

The design of the tiles in the borders are, in fact, a remarkable piece of design work, bringing together a strong sense of representation based on observation of "the natural" and the stylisation needed to create ornamental and chromatic rhythms that bring movement to this south-facing façade. The lobsters, crabs, corals, seagulls and different species of algae are designed for the children at the sanatorium so they can recognise them on trips to the beach, forming a kind of illustration associated with children's books at the start of the 20th century.

Fig. 3: Winter garden with the portrait of the sponsor, Amélia Biester, by Costa Motta, 1900

According to newspapers of the time, the painter Ricardo Ruivo, a brilliant student of the Royal Academy of Fine Arts, was commissioned to design the monogram of *Sanatório Sant'Anna*, two "S" interwoven with an "A", which is still used as the logo for today's hospital. The monogram was engraved in the glass of the internal doorways of the winter garden (with only a few examples on the doors next to the chapel remaining), and was also painted on tiles on the outer façade. The tiles were the result of cooperation between Ricardo Ruivo and a "studio" painter, Carlos Alberto Nunes, who was skilled in the use of stoneware pigments.

An impressive playful space inside the building, with large, south-facing rooms, absolutely unexpected in a hospital building, depicts a multicoloured garden in its tile decoration to welcome the games of the sick children – a winter garden. Created by Ricardo Ruivo, Jorge Pinto and Miguel Queriol, it is one of the most interesting examples of tile decorations in Portuguese art nouveau. The high lining of the walls, almost up to the ceiling, is subdivided into horizontal strips, each one likely relating to one of the artists involved in this perfectly integrated scene, finished with a spectacular series of sunflowers. The concave corners, entirely covered by tiles, are another independent artistic project, depicting pine trees with their foliage of needles and pinecones. It is, therefore, a playful space, with scenes formed of multicoloured tiling, medicinal plants, flowers and trees, designed to fend off fears and anxieties, encouraging optimism and well-being for children.

The chapel of *Santa Ana* (St. Anne) is located on the building's north façade. The elevation exhibits Neo-Romanesque taste, however, the interior has an "archaeological" revivalist nature, with some Neo-Byzantine features which can be noted in the murals and stonework, in an attempt to recreate a feeling of magical spirituality, also thanks to the play of colours that had almost disappeared in Portuguese Romanesque architecture

Fig. 4 and 5: Winter Garden decorative tiles

Here it is brought back in an almost literary and theatrical view of the Romanesque, a spirit that references the influence that Alexandre Herculano would have had on Rosendo Carvalheira. He used nationally renowned artists to decorate the chapel. António Augusto da Costa Motta produced the bronze bas-reliefs in the façade, Sant'Ana e a Virgem (St. Anne and the Virgin) and *Nossa Senhora da Misericórdia* (Our Lady of Mercy), and the white marble statue of *Nossa Senhora das Graças* (Our Lady of Graces), signed and dated 1900. Inside, we find *A Música Sacra* (Holy Music), in a patinated plaster frieze, and *Doze Apóstolos* (The Twelve Apostles), as a bust, integrated into circular medallions that adorn the space above the doors of the chapel and other areas in the side elevations. The chapel's six stained glass windows were created by António Ramalho: the depiction of the *Espírito Santo* (Holy Ghost), in the oculus of the main chapel; *Santa Amélia e Santo Frederico* (St. Amelia and St. Frederick), paying homage to the first founders, next to the chapel portal; and *São Francisco, Santa Ana ensinando a Virgem a ler e São Fortunato* (St.Francis, St. Anne teaching the Virgin to read and St. Fortunatus).

HOSPITAL DE ALCOITÃO (ALCOITÃO HOSPITAL)

Another hospital building, also found in the Cascais area, *Hospital de Alcoitão* (Alcoitão Hospital), also warrants attention thanks to the quality of its pioneering implementation of the most up-to-date physiotherapy treatments, comprising several aspects of rehabilitation in a high-quality, modern building designed by architect Formosinho Sanches. In fact, there was a need to perform new types of treatment at a specific centre for illnesses that affect locomotion and control of movement, among others. Treatment sought to encourage the recovery of lost abilities in order to give the patient an independent and socially dignified life, performing the tasks of everyday life, and even working, which would also provide them with economic independence.

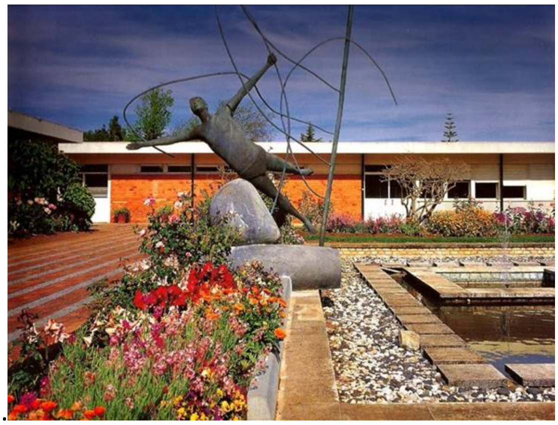

Fig 6 Central patio with metal sculpture, by Martins Correia

The site in Alcoitão was chosen because of its physical and climatic conditions – a high point from where, at a few special spots, the sea to the south and the majestic silhouette of the Sintra hills to the northwest can be seen. At Alcoitão, situated 3 kilometres from the beaches of Estoril, the atmosphere is relaxed, at once maritime and, although decreasingly rural, set away from the pollution of towns and cities. The Alcoitão Rehabilitation Medicine Centre comprises a range of buildings, gardens and surrounding park.

In the central body of the building, the horizontal nature of the one-story building stands out, along with the calm and welcoming expression of the buildings, as a first encounter at a human scale, also asserted in the metal sculpture by Martins Correia in the patio, a human figure, which can be seen from the building's entrance. As in a Roman house, the common areas that are designed for people to circulate and meet were built around a central patio: entrance hall, waiting rooms, diagnosis areas, administrative services and the former school area.

The search for human-scale, emotional values can also be seen in the noble truth of the materials, shaped with a functional and above all aesthetic sense. Iron, glass, masonry and brick were used. Brick, rare in Portuguese construction and even more so in hospital buildings, appears as an external covering material that introduces warm tones and interplays of light and texture to the façade. The brick walls of the main façade continue into the inside of the entrance hall, increasing the blurring of the boundaries between gardens and internal areas. In this building, the use of natural materials (like brick) on the outside, invading some internal areas, as we have seen – wood, above all in ceilings and fixed and movable furniture, stone in the lining of the floor at the entrance– comes from the organicist aspect that we have looked at previously. Even in the design of the flooring of the sculpture patio, connecting brick and stone around a pond, the chromatic and tactile qualities of the materials are exquisitely explored.

Lighting for the building is provided by the large glass openings and transparency between the different spaces, as a form of natural lighting. When this solution is not possible, skylights are included in the main corridors and outpatient waiting room, forming a rhythmic series of circular openings that create, on the external roofing, a characteristic system for allowing light to enter. This option had already been used, to great effect, in the courtroom at the Rio Maior Court.

The influence of the architect Mies van der Rhoe can be detected in the issue of materials and architectural design. Note the aesthetic use of large glass surfaces that pursue the effect of transparency and luminosity and, above all, in the exposed iron supports, specifically the U-shaped beams in the main façade. The canopy at the building's entrance, floating in space, is a strong element in the vocabulary of modernism that definitively abandons the classical systems used to monumentally signal façades.

Wood, which is greatly appreciated by Alvar Aalto, was used at the Alcoitão Centre in fixed and movable furniture and in details, such as the exquisitely designed handles for the glass doors to the patio. As an element of great refinement for a hospital building, wood is also the material used to line ceilings, functioning as sound insulation and at the same time ennobling some areas, such as the entrance hall, some internal corridors and the complex internal lining of the auditorium. Other internal lining materials include marble in the entrance hall and, in particular, linoleum as the surface for most of the flooring, carrying a pleasing black-and-white checked design. Linoleum is a highly resistant material that also works as sound insulation.

Some of the Formica wall lining (a covering supplied in rolls and glued to the wall like wall paper) remains. Its texture is similar to that of linen or flax, with colours ranging between greys and blues and, although the colours have not stood the test of time well, it was in fact an excellent solution for the wainscot. The architect also used a relatively uncommon lining at the time – cork – for both the ceilings of the chapel and the auditorium to provide the sound insulation needed.

At these two hospitals in the Cascais area, the quality of the architecture, care in the choice of materials, the contribution of art and the careful use of colour contribute to human comfort to overcome and relieve weaknesses.

ACKNOWLEDGEMENTS

Santa Casa da Misericórdia de Lisboa and Francisco d' Orey Directorof the Archives

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AIC LISBOA 2018
colour & human comfort

Colour Experiments in my Imaginary Universes

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ABSTRACT

Colour is, as scientifically established, the light reflected or absorbed by matter as perceived by the human eye. Although the laws of physics are considered universal, in the unknown cosmic space these conditions may not be the same. The colour is, therefore a phenomenon that results from our view of the world and that may also involve other brain abilities that are not currently known. Based on this principle, I have been experimenting various abnormal situations that disturb our common vision without surrealizing. Since the colour is a very vast world of research, all the experiments I undertake are about colour-pigment. In this presentation I summarize how I have been addressing the issues of light, depth and dimension fundamentally related to the use of colour, in universes that are my own creation.

Keywords: colour, dots, light, space, universe

INTRODUCTION

Much of the Art in Antiquity has been coloured (constructions, sculptures, etc.). The painting has almost disappeared and the materials have been destroyed/deteriorated with time resulting in an incomplete vision of the past. I then imagined the great ancient temples twinkling in wonderful colours. Similarly, looking at the sky and the infinite points of light, almost always white or yellow, I had the notion that all these stars could be of different combinations of colours, many of which may not be captured in the luminous spectrum as we receive it. It must also be present that the Cosmos we witness is a vision of the past. All stars and galaxies are at an incredible distance of light years and are not what they are, but what they were in very distant times. That is why I devised a cosmogonic vision in which the universe is represented in the present time. If I'm not then able to travel at an instantaneous speed or higher than the speed of the light and move in real time everywhere, then I use the imagination as a transport for that journey. What we see and know are just traces and ruins of a past where the colour has disappeared. I believe that the cosmic infinity, the whole universe, exists in the deepest of our own being. We just need to search for it, like in a game of mirrors, lenses and filters that are reflected indefinitely, interfering with our perception at every moment. One can call it soul, spirit, God, or any other metaphysical concept. Trying to get to the bottom of ourselves is to look for the universal that exists in everyone. The unknown origin. Nothing is therefore more ephemeral than the act of painting and more convenient to the consciousness of our brief passage through the world and through time.

Many authors claim that art is emotion, it cannot be explained. I largely agree and my work emerges through steps of my own evolution. Much of my work is a result of random circumstances, of the unknown and even of failed experiments which are then used in other contexts.

EXPERIMENTAL

My interest in colour started in 1969/70 using the theme of the Cosmic universe that has always fascinated me. At the time, the pictures of the astronomy books were generally in black and white. There were no powerful telescopes that would subsequently unravel the false chromatic richness of the galaxies, artificially treated. It was a new world and I began to use fluorescent colours, which I never abandoned, to get more light and chromatic vibrations. I called these works "Volumes in Space" (Figure 1 left), shapes cut out on flat funds, floating in space in different perspectives.

However, I did not immediately continue on this path, which tended to an abstract/material representation. Abroad, where I lived, I dedicated myself mainly to cinema, another great passion, along with photography. For a few years I made several films and this experience of creating atmospheres, the scenic game of light and shadow, the framing, the movement of actors, the continuity of action, human contact, editing, etc., was very useful in my activity as a painter. In 1974, I painted several zones in blue (e.g., trees, portions of land, ditches, etc.), in several European countries, that I photographed, dated and exposed. This was "The Journey".

Oddly enough, I felt the need to "return to Earth" and define plastically, in a more precise way, an idea I was trying to convey. During those years I still painted (mainly drawings) landscapes from other sidereal worlds, the series of "Outer Landscapes" (Figure 1 right). I shortened the palette to a mixture of cobalt blue with aluminium, outlining the shapes in black with some coloured dots and tone bars. They were presented as quasi-graphics, with diagrams detailing the nature of the imaginary planets, photographs, annotations of their cartography, geology, orography, atmosphere and other explanatory notes.

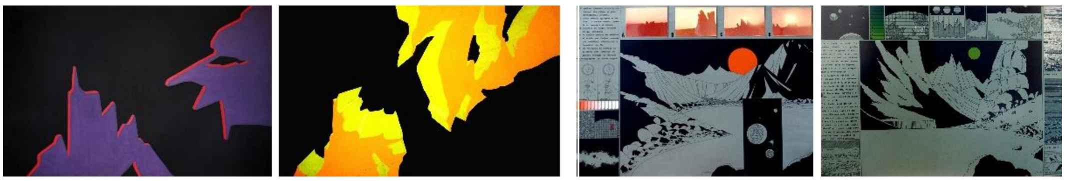

Figure 1 Left: Volumes in Space (1969/70), tempera on wood, 85 x 140 cm each; right: Outer Landscapes (1971/77), drawing on paperboard, 50 x 65 cm each.

From 1978 to date I started the "Katalog–Catalogue of Celestial Bodies" aiming at painting the Cosmos. And since 2005, I purposely followed a traditional route through painting/painting and not using electrical processes or new technologies. I spent a few months experimenting techniques of creating depth in the backgrounds that would make the impression of a third dimension. I tried various types of plastic paints and acrylics painted with a paintbrush or a roller, several shades of black and dark blue, but the result was a surface too flat, a one-dimensional barrier. I then moved to spraying several overlapping layers of the same transparent or translucent ink. I finally opted for the Prussian blue which approaches to my perception of the cosmic space. To populate this territory, I subsequently began to use a pictorial system based on points, sprays (which are billions of points), airbrush, various types of paint projection, metallic colours (highlighting the brightness and varying according to the angle from which they are observed), and fluorescents (which require special treatment by absorbing invisible ultra violet light and emit more light than they receive). I also used several other exploratory techniques in which the ink droplets are not the random result of an abstract expression but, on the contrary, are real objects. From each dot/point treated individually, as if it was a star or planet, my experiments lead to a visually recognized atmosphere but somehow disturbing. So, to get more brightness, the droplets were painted blank and subsequently covered with several ranges of colour, one by one, looking for the tones that would best create an atmosphere of its own. I used, for instance, violet with lemon yellow, cerulean blue and phtalo blue with aluminium, fluorescent red with silver, etc. These were the “Galactic Charts” (Figure 2) where I randomly catalogued planets, stars, galaxies and other imaginary celestial bodies, in a poetic attitude of confrontation between art and the science of observation, utopian images of the universe photographed by telescopes, but in which the universe was only an excuse to explore colour. I also used diffusing areas in lighter or even metallic tones which, by their density characteristics, could not be diffuse. I continued to experience new shades, mixing pigments, using sprays for car paint and other techniques stolen from other uses. I purposely joined principles of subtractive and additive synthesis. At that time, I also started the "Stellar Atlas", hand-painted notebooks and real test tubes of my experiments with colour.

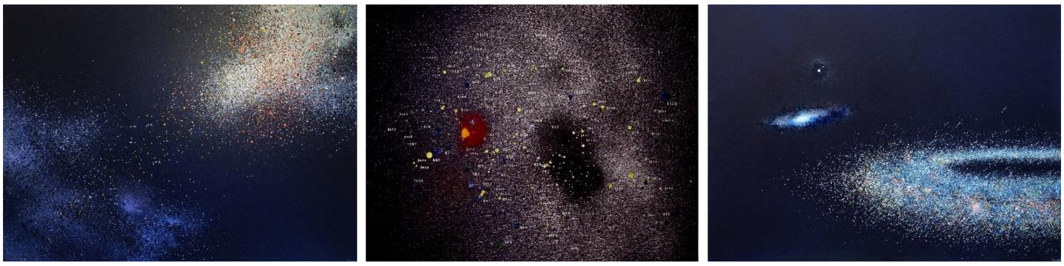

Figure 2: Galactic Charts (2005/2006), acrylic on canvas, 110 x 150 cm each.

So, I have been creating cosmic universes that obey their own laws: inverted eclipses, unintentional shadows, colour games that do not follow the rules of classical astronomy. It is artistic creation where the ramblings of the imagination are allowed.

In this presentation, as I am unable to address all the experiments with colour I have been undertaken, I chose to focus more on three or four periods of my work in which colour had more relevance in my "démarche". During the years of 2006/07, I painted the "Cosmic Points" (Figure 3), three panels of 200 x 200 cm each, composed by 75 smaller canvas, in which I synthesized the vision that resulted from my previous work. I addressed three possibilities of colour treatment in space. “Cosmic Points–Light” (Figure 3 left) in black or blue backgrounds presented as a space-environmental matrix with the inscription of varying celestial bodies, stars, galaxies, etc., and where the colour is presented as a light magnet. I purposely used luminous or clear colours that gave the impression of bathing the surrounding bodies in a more realistic view and according to our own conception of how to present space objects radiant or illuminated by exterior, but hidden, lights. These bursts of light tend to create the idea of a slow movement, almost imperceptible to our eyes, and are apparently farther away than the points in the first plans. They are often treated with colours that unmake that same illusion, or are lighter than the main light, or were painted with secondary and intermediate colours in softer or darker shades, or have autonomous illumination, creating a subtle game of unlikely depths. In “Cosmic points – Counterlight” (Figure 3 middle), the space is made up of thousands of points where the main stars mingle and stand out in the immensity of other points. There, the game of colours is presented as a spatial plot, more or less uniform, in which each works as an element of a set or stands out by contrast hot-cold, different gradation or luminosity. In this case, the space is treated as a vibrant atmosphere and a territory populated by a myriad of autonomous galactic bodies that co-exist. Finally, in the third panel, “Cosmic points–Reflexion” (Figure 3 right), I experimented various metalized backgrounds (ranging from aluminium, silver and copper) or warm and vibrant tones (magenta, yellow and oranges) where colours undergo certain chromatic changes, creating unforeseen spatial atmospheres and where the brightness is given essentially by contrast or by the vibration of certain colours or their differentiated degree of saturation.

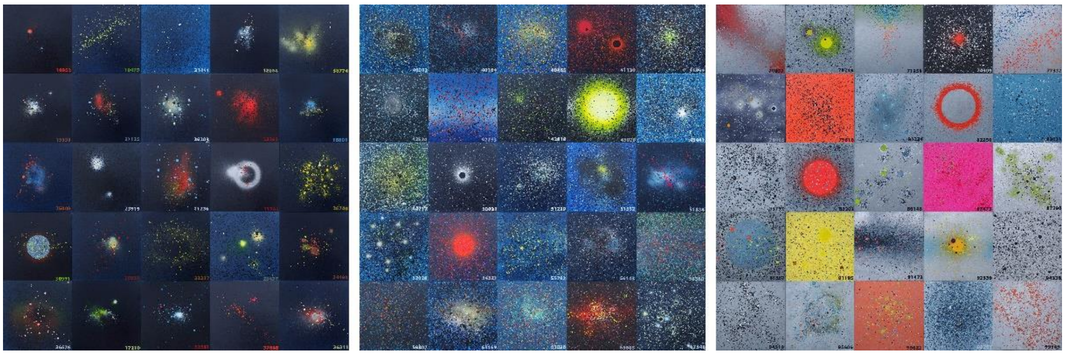

Figure 3: Cosmic Points (2006/2007), mixed media on canvas, 200 x 200 cm each; left: Light; middle: Counterlight; right: Reflexion.

In 2008, I performed a series entitled "Spectral Studies" (Figure 4) in which I developed spectral ranges of some true stars, others invented, and the solar spectrum. At that stage I was essentially interested in the study of the illusory movement, because although the Cosmos is in perpetual motion, the apprehension that one has is that everything is stopped. In fact, some colours seem to move faster than others because of their dynamic characteristics. This effect can also be obtained by their different disposition on canvas, by the order of magnitude of the bodies themselves, etc. In this infinite game of possibilities everything can be subverted and that is what I try to do. A coloured point within another point of different colour highlights the colour that you want to highlight (if black or white) or works as a vibrating element (in the case of a secondary colour, for example). An extension of coloured dots in various shades or varied colours creates the impression of luminous continuity. The absence of shadows contradicts the notion of a classical illumination that can be given by the use of different colours. The light can also be manipulated by the use of colours, depending on its scale, intensity or uneven saturation. These phenomena are, however, not found in known images of the visible universe. The elaboration of an ink drop as a celestial object may create the suggestion that the other points are equally distant stars.

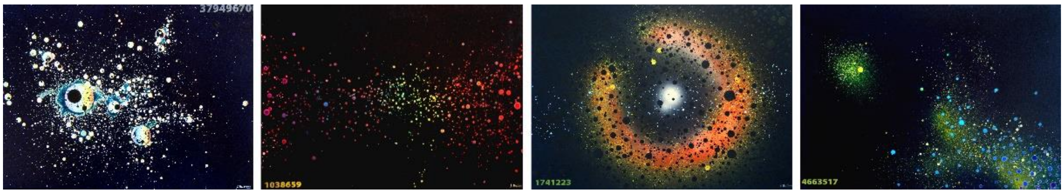

Figure 4: Spectral Studies (2008), acrylic on canvas, 50 x 75 cm each.

As everything that exists is comprised by dots (atoms, particles, planets, etc.) and it is thought that the infinitely great obeys to the same laws as the infinitely small, I also dared to explore the sub atomic world in the same way as the universe cosmic, allowing me to use various colours in metallic or fluorescent backgrounds. For example, yellow is brighter on black background than on a neutral surface. A larger point seems closer than a minor point. Hot colours approach and cold colours increase the distance. The movement can be suggested by displaying the colours in space. However, all of this can also be exactly the opposite, according to the surrounding context. This period was culminated by two large panels (7 meters long each), the "Expanded Galaxies" (Milky Way and Andromeda) in 2008/09.

Figure 5: NeutrinoPhaseOne (2010/11), mixed media on PVC, 100 x 100 cm each.

In the next phase, the "NeutrinoPhaseOne" (Figure 5), followed the third panel of the "Cosmic Points" mentioned above. I abandoned the canvas for a totally rigid and smooth surface (PVC in aluminium). This allowed me to explore the perception of vacuum (or absence of atmosphere), a system in which the depth of the illusory space, the apparent movement and the light, could exist. The intensity of the colours, the variety of tones and the very characteristics of the pigments were altered accordingly.

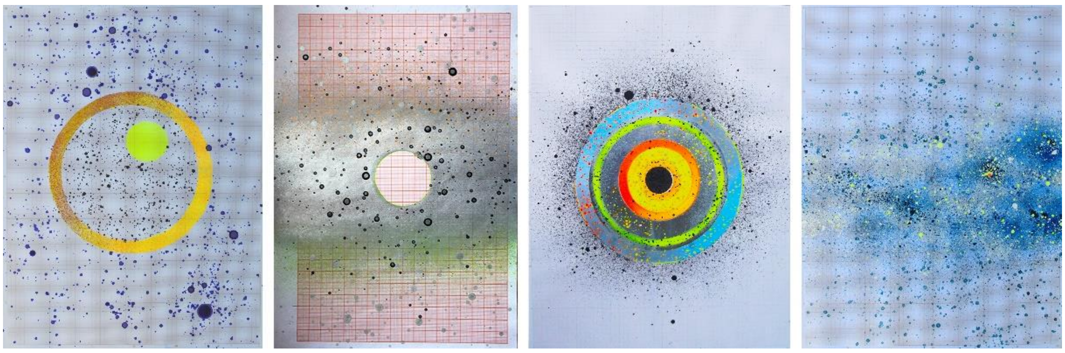

Figure 6: Nebular and Globular Hypothesis (2011/15), drawing on millimetre paper, 21 x 30 cm each.

Then I felt the need to return to my usual passion of cataloguing utopia. For three or four years (2011/15), I painted almost two hundred drawings on millimetre paper, the "Nebular and Globular Hypothesis" (Figure 6). I used the grid as a tool of scientific accuracy and painted miniatures of an imagined future. There I explored different graphic effects, using caches and counter-caches, universes inside and outside other universes, auras, reflections, compositions based on optical illusion, eruptions of colour, and created the illusion of spaces demarcated at different distances. The white background of the paper, where the colours are highlighted, provided greater accuracy of the forms and guided the next phases of my evolution.

DISCUSSION

More recently (2016/17), and after all the experiments mentioned above, I returned to the canvas and coloured backgrounds, where I created new and endless associative games, contrasts, chromaticism and different perceptions of colour, always creating the illusion of a three-dimensional space in the "NeutrinoPhaseTwo". How do colours work in fluorescent backgrounds or composites, i.e. celestial bodies on top of stars that cover the entire frame? Are they in backlight or can they exist autonomously in an effect that photography could not capture? An opaque body illuminated from behind can be presented as getting an invisible front light and losing its silhouette features? And can the colour of these bodies inhabit harmoniously with the coloured background without losing the illusion of greater proximity to the spectator? I also used bands of chromatic circles, in a game between what is seen in the picture and the chances of other ranges of colour of these same stars.

With the two new series, "NeutrinoPhaseThree" and "NeutrinoPhaseFour" I worked with chrome painting and new reflective materials, looking for the light that is at the basis of all colour as perceived by the human eye, in a different approach perhaps closer to spiritual meditation and iconic atmospheres. Finally, in the "New Galactic Charts", large paintings not shown here and which I will present in a forthcoming exhibition, I synthesise all my previous experiments, a mixture of the cosmic universe and the macrocosmos.

CONCLUSION

My paintings results from practicing error, correcting and making new errors, from attempts that harmonize or contrast in my always dissatisfied look over the world, using unlikely chromatic combinations or effects beforehand sought. I search for harmony that can be surprising but that is an essential element of the genesis of human creation. My own discovery as a creator. Utopia perhaps, but a good justification for a painter. What is the world? How to transmit it through colour and space in a virgin environment, without existential references and therefore almost symbolic? Despite all these years of searching for a different language but spontaneously natural, I feel that the more solutions I encounter the more doubts I face. To try is to find out. That is exactly what gives me the strength to go on.

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colour & human comfort

Colour from a gradualist perspective

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ABSTRACT
A gradualist perspective allows to explain many aspects of colour and visual appearance in a more appropriate way than the usual conceptions based on taxonomic divisions and categorial oppositions. We will deal with various problems associated with colour and appearance taking into account —rather than the usual oppositions, divisions, categories or taxonomies— the moments of transition, gradations and transformations that allow moving from one category to another, with a better understanding of how the relationships are produced and the ways in which those differences occur.

Keywords: *colour & appearance, gradualism, colour mixtures, scale factor, cesia & texture*

INTRODUCTION

The issues of colour and visual appearance[1] have been approached from multiple perspectives, but generally thinking them in terms of classifications, oppositions or categorial divisions. I propose to study various problems related to colour and appearance under the hypothesis that these aspects are better conceived in terms of gradations, intermediate situations, progressive changes, accumulations and continuous transformations between cases or situations.

This gradualist hypothesis is not a new idea; it appears flying over several areas of knowledge. Gradualism is found in certain perspectives within biology, geology and the natural sciences, where it has been part of evolutionary theory, as well as in humanistic disciplines such as social and political sciences, statistics, semiotics and other fields of knowledge, where it has proven to be more effective than oppositional or categorial classification systems. For example, the classification of the biological kingdoms has been constantly changing throughout history. From the classic division into two kingdoms (plants and animals) to the present, multiple categories and new divisions have been generated. Recently, two super-kingdoms have been proposed

[1] The concept of visual appearance includes categories such as colour, texture and cesia (see Caivano 1991, 1994, 1996), among others.

(eukaryotes and prokaryotes) within which seven kingdoms are recognized: archaea, bacteria, protozoa, chromista, fungi, plants and animals. Surely, these taxonomies will continue to be modified, until a point where there will be so many divisions that the zones of differentiation between one and the other become diffuse. Then, it seems that a hypothesis where the world is interpreted through gradations or continuous transformations, instead of tight divisions, may be less simplifying.

We will try to verify the generalization of this hypothesis, recognizing it in previous cases and extending it to other aspects of colour and appearance studies. Three antecedents that take into account this perspective in colour studies can be outlined.

1) Colour order systems and notations, which have overcome the limitations of colour names.
2) Two steps in the studies of linguistic and cognitive categorization in the domain of colour: Berlin & Kay, plus MacLaury, which are unavoidable to understand how cultures and languages incorporate basic colour terms.
3) The semantic differential scales, a method that has brought greater depth and rigor in the treatment of colour semantics.

These are just a few but paradigmatic examples where we can see gradualism applied with success in colour studies.

ANTECEDENTS OF GRADUALISM IN COLOUR STUDIES

1. The case of colour order systems and colour notations

Colour names are a very limited option when it is necessary to identify different tones with certain precision. This limitation is overcome by colour order systems, with their notations that combine signs of verbal language with numbers, allowing to refer to the millions of distinguishable colours with accuracy. Verbal language alone cannot do that. Colour names refer only very generically to certain colour sensations. These names can be modified by adjectives that refer to lightness and saturation (light red, medium red, dark red, pure or saturated red, grayish or desaturated red, etc.). But this is not enough, and is further proof that verbal language usually operates in terms of oppositional categories, hiding the intermediate gradations and concealing how something is transformed step by step into something else.

However, the combination of these categories with numerical scales does allow to differentiate millions of colours and to account for their gradation and transformation. For example, according to the Munsell notation system (1905), we can differentiate R5/4/8 (red 5, value 4, chroma 8) from R4.5/3.5/8.25 (red 4.5, value 3.5, chroma 8.25), which is slightly different from the former. There are many precedents about notations that register graduality in the variation of colour. One of the first is Tobias Mayer notation for its chromatic triangle of 1758. Among modern cases, we find Munsell notation in 1905, the colour systems and notations by Ostwald in 1917, Villalobos-Domínguez (1947), Hesselgren (1953), Küppers (1978), the Natural Colour System (SIS 1979), Colouroid (Nemcsics 1988), and many others.

Colour order systems may serve as models to think other systems of signs that operate from the graduality and allow the description of different aspects of the world. There are always intermediate states between one thing that becomes another. It is the verbal language, with its categories, that conceals those gradations.

2. The case of basic colour names: cognitive categorization in the domain of colour

The proposals by Berlin & Kay (1969) and MacLaury (1997) are unavoidable to understand how cultures and languages incorporate basic colour terms. Colours are a perceptual continuum.

According to the conditions of observation, humans are able to discriminate about three to eight million colours. But when someone is asked to designate colours by name, he will only use a small handful of terms. Names impose divisions on the continuum of chromatic perception, and they constitute the limits of colour categories. As Berlin and Kay have found (1969), there are 11 basic colour names in most modern languages: white, black, red, green, yellow, blue, brown, purple, pink, orange and grey. These names represent chromatic categories, and all languages have terms for them. They are basic in the sense that they are monolexemic, have no relation to each other, apply to a wide variety of objects, and are used in a stable way by all speakers. The evolutionary stages in which these 11 colour categories appear are seven: 1) black and white appear in the first stage; 2) the third term that appears is red; 3) the fourth term that appears is either green or yellow; 4) if yellow appeared in the third stage, green appears now, or vice versa; 5) then appears blue; 6) after that, brown; 7) finally, the four remaining terms appear without a predictable order.

Robert MacLaury (1997) presents a theory on colour categorization that introduces important advances, since it pays attention to the moments in which a language is making a transition from one stage to the next. The data comes from a survey carried out in Mesoamerica, covering 116 languages. MacLaury develops a model of colour categorization called vantage theory, which is able to explain how human beings name colours by selecting points of view related to their spatial-temporal coordinates. This theory can account for cases in which the same colour stimulus receives two different names depending on the point of view taken by the speaker. MacLaury (1997: 111-114) found a speaker of the Uspantec language in Guatemala, who named several samples near red and yellow as *q'en* (yellow) or as *kyaq* (red). He designated the same samples with one or another name according to the category from which he started. When asked to mark what colours were *q'en*, he started from yellow and extended towards red; when asked to mark what colours were *kyaq*, he started from red and extended over the same previous samples, going towards yellow. MacLaury noted that this semantic relationship did not fit in the concepts of synonymy or near synonymy, inclusion and complementation, and called it coextension. Let's see these concepts (Figure 1).

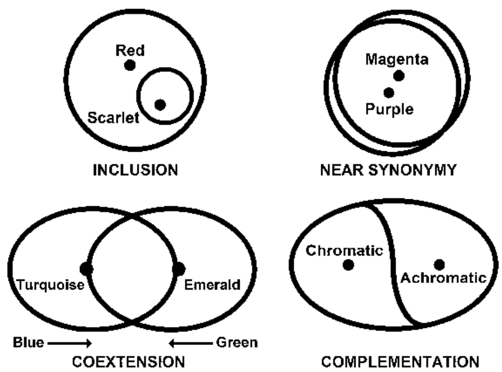

Figure 1. Diagrams that represent the semantic relations of inclusion, near synonymy, complementation and coextension. It is easy to note that between one situation and another there may be gradations (stretching from one area to another, increasing separations between foci, etc.) that explain the transformation of one relationship into another (Caivano 2010).

When different words designate the same objects, the relationship is synonymy or near synonymy. For example, "magenta" and "purple" designate a group of colours halfway between red and blue. Both terms have more or less the same semantic extension, and their foci are very close to each other. When a word designates a group of objects included in a larger group designated by another word, the relationship is inclusion. For example, "red" names a group of colours and "scarlet" refers to a smaller group that is a special class of red colours, i.e., "scarlet" is included within "red". A term has a semantic extension that is part of the semantic extension of another term. When a word designates a group of objects and another word designates a different group that is the complement of the previous, the relation is called complementation. For example, the category "colours" can be divided into the categories "chromatic" and "achromatic", both being complementary in this sense. The extensions of both terms do not coincide at all, they are independent, and only touch at their edges.

But MacLaury found speakers who named certain colours with a term when they considered them from a certain point of view, and the same colours with another term when they adopted a different point of view. Both terms were focused on different places of the chromatic spectrum (therefore near synonymy was not applicable), but their extensions covered practically the same colours (therefore inclusion or complementation were not apt to describe the situation either). The concept of coextension was adequate to characterize this semantic relationship. For example, a group of colours that are midway between blue and green can be designated "turquoise", when considered from the blue category, or "emerald", when considered from the category of green. The extension of both terms has a great overlap, but their focuses move towards different directions.

These relationships do not remain fixed in a language; there is an evolution. And in the evolution from one semantic relation to another, coextension and inclusion act as intermediate stages between synonymy and complementation. The different relationships are due to unequal emphasis given by speakers to similarity or difference. When close attention is given to similarity, near synonymy occurs; when attention is paid to difference, complementation appears; in the middle, a balance between similarity and difference produces coextension (similar in extension but with different focuses), while a moderate attention to difference produces inclusion (different but of the same class). This finding led MacLaury to propose vantage theory as a model that, without contradicting Berlin and Kay series, is more comprehensive and explanatory of the processes involved in the development of categories. It can explain the process by which a category is divided during the evolution of a language, due to a growing emphasis on difference. MacLaury research focuses on the gradual process that ultimately generates a categorial division.

3. The case of the method of semantic differentials applied to colour

While I will not extend on the explanation of this topic, I want to point out how the methodology proposed by Osgood, Suci and Tannenbaum (1957), often applied to studies of colour semantics, allows to understand these problems with greater variety, depth and rigor. It has thus overcome the trivial psychological or semantic associations of colour based on common sense correspondences, which usually only refer to stereotyped cases, without taking into account contextual variations. By using graduated scales, to which numerical values are ascribed, the method of semantic differentials has also made it possible to apply statistical tools to studies on colour from psychology, semantics and any field concerned with colour and emotions.

NEW PERSPECTIVES ON COLOUR AND APPEARANCE UNDER A GRADUALIST HYPOTHESIS

The three cases reviewed, where we find that the gradualist conception works effectively to understand the phenomena involved, constitute antecedents to think that it is possible to extend this interpretation to other fields of study and application of colour and visual appearance. In the next sections, this perspective will be applied to some colour topics that will be presented under a new light:

a) Chromatic mixtures understood as a gradation with intermediate steps, instead of the classical separate categories of additive, subtractive and partitive.

b) Gradations in cesia and texture: how the scale affects the transitions between visual categories.
c) Chromatic vs. achromatic sensations: reductio ad absurdum of the misconception that greys, black and white are not colours.

a) Chromatic mixtures understood as a gradation

It is usually admitted that there are three types of colour mixtures: additive synthesis (superposition of lights), subtractive mixture (pigmentary), and partitive mixture (optical). Characteristics of each type are described in this way: additive mixtures produce lighter colours, subtractive ones, darker colours, and partitive ones, colours of average lightness among the mixed colours.

But in many cases, it is difficult to classify a certain type of mixture. For example, in the case of pigmentary mixture, if we work with transparent dyes or inks, a subtractive mixture is certainly produced (each layer of pigment applied on a white background subtracts some radiation, and the result is always a darker colour); but if the pigments are opaque, the result of the mixture, in terms of lightness, will depend on the degree of diffuse reflection produced by the pigments. Now, the scale between transparency and opacity is a continuum (and it can be difficult to speak of perfect transparency and perfect opacity for a given thickness of pigment layer), as well as the variation between diffuse reflection and specular reflection (and in practice there is no perfect diffuse or specular reflection). Then, it would be better to develop a model of colour mixtures that, instead of proposing sharp divisions, offers the possibility of understanding how gradual variations occur between one case and another.

Harald Küppers (1978) addressed this issue when developing his "laws of colour synthesis": *additive synthesis* (e.g. colour television), *subtractive synthesis* (e.g. colour photography), *layers of translucent and opaque colour* (paints applied in overlapping layers), *integrated mixture* (opaque paints mixed with each other and then applied in a single layer), *optical mixture* (small colour dots that cannot be perceived individually and are integrated), *rapid mixture* (colour stimuli at very short time intervals). Küppers asserts that "there are at least eleven laws of colour mixture. Although every mixture strictly follows its own laws, each case it is a possibility of interpretation of the way in which the organ of sight works" (1978 [1980: 177], my translation).

With this in mind, there are various types of mixtures that can be investigated under a gradualist conception:

Lights:	• superimposed or overlapping • adjacent, in small size (without superposition or overlap) • intermittent, in fast sequence
Opaque pigments:	• mixed in powder form • mixed with water in paste form (graduating the amount of water) • totally diluted in water
Translucent pigments:	• with decreasing turbidity (from near opaque to near transparent)
Transparent inks:	• previously mixed and applied in one coat • applied in successive coats, waiting until the previous is dry
Small colour dots:	• overlapping • adjacent • separate (a white background seen in between)
Spinning colour surfaces:	• with matte finish • with glossy finish

b) Gradations in cesia and texture: the problem of scale

The scale from which an object is observed affects the transitions between the categories of texture and cesia. Dardo Bardier (2003, 2007, 2010, 2013) points out the ranges and limits of perception in terms of perceptual scales. What on a certain scale is perceived in a way and stimulates certain types of receptors, on another scale is processed by other sensory receptors and produces completely different appearances, or is not perceived at all. For example, the variation of size and density of a texture has a certain range within which it is visually perceived as such, but on a smaller scale it begins to visually affect the perception of cesia.

The differences between glossy and matte, as well as between translucent and transparent, are related to this. In a scale of gloss, for example in the one produced by the Scandinavian Colour Institute (SCI 1996), the micro textural variation on the surface can be observed with a magnifying glass or a microscope: the loss of gloss is associated with the increase in surface micro-roughness. This effect has been studied by Béland and Bennett (2000), and was already recognized in the visual method to evaluate brightness proposed by the ASTM (1990), with antecedents in the pioneering studies of Hunter (1975). Now, if this roughness is perceived by the naked eye, it is appreciated as a textural effect and not as a cesia. The same could be said about the variation between transparent and translucent.

In his general scheme of visual appearance, Lozano (2006) places the variable of diffusivity in cesia next to the category of spatiality (which includes roughness, waviness, and the effect known as orange peel), which in turn connects with the category of texture. This supports the idea that the visual categories of texture and cesia are close to each other, are strongly related, and can be studied in several aspects in terms of gradations based on scalar variations.

By means of experimental designs, observations and measurements, these limits can be investigated, particularly the moments in which one category is transformed into another, and also how micro texture influences the variations of cesia.

c) Chromatic vs. achromatic sensations

Many people consider that greys, black and white are not colours. Sometimes it is said that white is not a colour but "the sum of all colours". This confusion may come from misinterpreting the experiments and conclusions of Newton, considering colours only those resulting from the dispersion of light, i.e. the spectrum of different wavelengths. If only they were colours, then magenta or purple would not be colours, since they do not appear in the spectrum, nor does brown and other tones that do not have a specific wavelength but result from stimuli composed by a mixture of different wavelengths (such as white!). Contradictorily, white often appears as "the absence of colour". When pigments are used on a canvas or paper, white is the surface that remains unpigmented, unpainted, without "colouring" (although obviously a white pigment can also be applied). Sometimes white is also referred to as absence in metaphorical terms. This reinforces the prejudice that white is not a colour: a "blank mind" or a "blank sheet" is something empty of contents, ideas, strokes ... colours.

The same confusion usually occurs with black. It is said to be the "sum of all colours" when a blackish tone is obtained from the mixture of various pigments, and the "absence of colour" when all luminous radiation is eliminated. In this last case, colour is considered a synonym of light; consequently, if there is no light there is no colour.

All this is wrong. White, black and greys are also colours. Because colour is a visual sensation (product of the interaction of luminous radiation with pigmented objects and observers, but finally a visual sensation). In other words, pigment and colour are not synonyms; luminous radiation and colour are not synonyms either. And just as we have visual sensations of red, green, blue, yellow, brown, magenta, etc., we also have visual sensations of white, black and grey.

A research was initiated on this topic through an online questionnaire and a survey of bibliographic sources. These studies can be complemented by asking a representative group of observers (particularly among those who answered that black and white are not colours) to indicate in a series of light and dark nuances close to the grey scale, where they see that "colours end". The difficulty in establishing this point, or the contradictions and differences among observers, would offer a demonstration by the absurd. If we understand colour as a sensory continuum with gradations in all directions (hue, saturation, lightness), we should admit that any of the extreme points in the saturation and lightness scales are part of the same category, i.e. colours. Since it will be impossible to determine by means of small perceptual differences a net point of separation between "colours" and "non-colours" we must conclude that all them are colours.

CONCLUSION

The aim of this paper has been to exemplify the generalization of the gradualist hypothesis, recognizing where it was applied in previous cases and extending it to other aspects of colour theory. I am convinced that methods that employ a gradualist conception are more suitable for studying visual phenomena — because of a greater affinity with them— than those approaches based on typical binary oppositions or categorial classifications, strongly anchored in verbal language.

In the field of semiotics, which can be taken as a methodological frame for many disciplines, binary or oppositional models of the processes of signification offer relatively poor possibilities. Instead, the model of semiosis proposed by Charles S. Peirce (1860-1908), although uses categories defined in a triadic way, can explain through extensive combinatorial possibilities the great variety of semiotic processes. Thus, an icon can be gradually transformed into an index or symbol, there can be mixed forms (indexical icons, symbolic icons, and other kinds of hybrid signs); signs can function in one way in a certain context and in a different way in another context. That is to say, nothing is static or pigeonholed; there are always gradual transformations, and thus intermediate states.

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colour & human comfort

50 Years of Colourful Reflections

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ABSTRACT

Fifty years ago, when I was first appointed to device a course of Architectural Psychology to the students at the Oxford School it was a big challenge to find a balance between desirable, relevant and needed material to improve the newly founded BA degree, approved both by both the CNAA and the RIBA.

The aim of this written and visual presentation is to critically evaluate the development of how colour was integrated and taught over this period of time, in both theory and practice and how students responded to it. What were the various theoretical and practical landmarks, events and people involved. From the development of the NCS by Hard in Stockholm, Sivik in Gothenberg, Acking and Kuller at Lund to the energy and enthusiasm of the founding members of the Portugal Colour Group in 2003, hosting in 15 year, this Interim Conference in 2018 in Lisbon.

Keywords: *diachronic reflections, architectural education, gender, the future.*

INTRODUCTION

Vitruvius wise words 40 BC were as relevant then as there are today. Perhaps, to try to bring the main issues in sharper focus in this century one should add, (brackets are mine)

> *"Let him (**or her**) be educated, skillful with pencil, instructed in geometry, know much theory, have followed the philosophers (**and experimental psychologists**) with attention, understand music, have some knowledge of medicine (**and neurophysiology**), know the opinions of the jurists (**and ordinary people**), and be acquainted with astronomy (**computer science**) and the theory of the heavens".*

In the world of colour knowledge, there was when I started very little to keep Vitruvius happy. One could find the odd history lecture on Ictinus and Callicrates on the painted exterior frieze of the Parthenon, as seen in the colour reconstruction of the Royal Ontario Museum. In Theory classes there were references to Richard Gregorys' visual illusions and in the First year studio, a design and build project of the Red and Blue chair designed in 1917 by Gerrit Rietveld.

Over the next 50 years the picture changed dramatically. The intake of women studying architecture rose from 7% in 1968 to 23% in the 1980's to 35% in 2014 and to over 50% in 2018! We followed both genders psychological profiles over these years, using the Rothwell Miller Interest Blank, and noted that women recorded stronger interests in aesthetics (including colour) literary and social service areas. This was also noted by the distinguished architect John Outram in 2009.

> *"When it comes, in any of my projects, to decide on colour, a sort of quadrille takes place. The girls step forward and the boys step back. The male incapacity with colour must derive from the gender stereotype. Boys stop playing with crayons at the age of five. Girls never stop playing with clothes, make-up, hair and then interiors. Women have an intuitive grasp of colour. It is nothing but a skill born in experience. Practice makes perfect. The only men who are capable are those who use colour in their work."*

The library was subsequently enriched by many new books on Colour, IAPS and AIC Colour Conference Proceedings, the NCS, Josef Albers famous Interaction of Colour Set, The Ishihara Colour Blindness Test, and the latest books by Lois Swirnoff, Harold Arnkill in 2013, Janet Best and Karin Fridell Anter books in 2017. Students took end of years compulsory colour exams, chose self-activated colour experiments, did their theory dissertations on colour in year 3, and wrote theses in year 5.

One of the most critical considerations over the years was in bringing directly the work of distinguished architectural practitioners and artists into the students' awareness and thoughts. Changing attitudes were also discussed. Norman Foster, for example, managed to get a blue building approved in the 1970s by arguing it was a greyish blue building, in an area of strict colour regulations. Similarly, Bill Heine's Headington shark on the roof of his house, took 40 years for the planners minds of the Oxford City Council to change a demolition order to a preservation order in 2017!

EMPIRICAL STUDIES, COLOUR KNOWLEDGE, INTEREST, ROLES

Over the past 50 years there have been many conferences, symposia seminars all over the world in an attempt to bring together architects, artists psychologists and other scientists to stimulate discussion in interdisciplinary research and practice. It was timely then to critically evaluate the extent this knowledge of the theory and practice of colour was transmitted in the teaching. Students' knowledge on the subject was tested in Universities in Britain and Sweden in the only empirical cross-cultural published study on the subject (Janssens and Mikellides, 1998). Longitudinal research at the Oxford School of Architecture over 40 years investigated also students' reported interest on colour compared to other areas of human aspects of design

The results of this cross-cultural study based on the responses of 448 students in 5 schools of Architecture in Sweden and England show that we are doing too little to educate future practitioners in the Art & Science of colour. Students expect more than they get; students also consider it very much part of their education and responsibility in the real world, yet there is a considerable gap between what is known, practiced and researched and taught.

There is no doubt that if Vitruvius observation more than 2000 years ago, that Architects should know and synthesize what there is to know without fear has not changed over this period.

There is still much to do and communicate this knowledge in the most appropriate way not only to practitioners but also to the very people who appear to be so keen to learn about it, the students themselves, who consider it their responsibility to put it into practice. In fact, there is the EEC Directive 3 prescribing that architects should have this knowledge.

OTHER COLOUR TOPICS TO BE CONSIDERED IN ARCHITECTURAL EDUCATION

With regard to what aspects of colour knowledge can be imparted to the prospective architects and practitioners one could consider some of the following topics listed below:
The historical perspective of colour in architecture. The study of colour meaning and psychophysiological effects. Colour aesthetics and learning from nature. Colour preferences and gender. Colour philosophies on chromatophylia and chromatophobia. The effect of modernism, new technologies, materials and economic climate. Lighting up architecture and the future .Lets consider briefly two or three of these.

COLOUR PSYCHOLOGY

Colour psychology involves studies of colour meaning and the psycho-physiological effects of colour and light on our emotions. Rikard Kuller's mammoth Annotated Bibliography of 1700 references of colour and light commissioned by Commission Internationale de l'Eclairage (CIE) firmly established the importance of three systems mediating the non-visual effects of light and colour on the cutaneous system, the pineal gland and the reticular activation system.

Over the years we know how colour affects our visual perception, making objects look heavier or lighter, planes to advance or recede, overestimate or underestimate the perception of time, make interior spaces to feel warmer or cooler or even sounds to seem softer or louder. We also know that colour can be used decoratively, therapeutically and symbolically based on the richness of cross-cultural customs and practices by both genders. Colour is also part of nature's survival kit for the functions of camouflage, attraction, protection and warning. Current research uses different colour stimuli and different methodologies for studying the effects of colour on humans, cognitive, affective and subjective measures on the one hand and physiological measures on the other. For example, the question whether red is more activating colour than blue is studied by reference to two opposing schools of thought. One is based on colour light and measured by physiological changes in the central and autonomic system and the other is based on colour pigment applied interior and exterior spaces while varying the dimensions of hue chromatic strength and lightness.

The importance we attach to our perception of light and colour and its emotional effects upon us, is not only celebrated by artists, poets and architects, but arousing passions among different scientists trying to understand and measure its effects upon human beings and life itself. Experiments have also been done in simulated spaces as well as full scale red and blue spaces experienced by the participants over time.

LEARNING COLOUR FROM NATURE

Prof Nicholas Humphrey is a distinguished British psychologist whose work on evolutionary psychology and aesthetics, the evolution of consciousness, cognition and sensory perception has contributed greatly to our knowledge of the subject. Humphrey suggested that "our ability to see colour evolved only because it contributes to our biological survival". He went on to say that designers who are now more than anyone responsible for colouring our world… can recognise and build upon on human’s biological predisposition., they might do well to study how colour is used in nature. Nature, has after all, been in the design business for over a hundred million years.”

For over 25 years, first year architectural and interior architecture students of the Oxford School of Architecture have been going out to Westonbirt Arboretum in Gloucestershire during the last week of October in search of both synchronic and diachronic rhyme in nature. Rhyme that can be found in the relationship between the perceived elements and rhyme experienced through temporal changes brought about by light, the weather, day any night and the seasons. In 2004 over 3000 visitors to the Great Hall at Westonbirt visited the first year students’ exhibition comprising the understanding of both the theoretical concepts and their translation in stunning architecture images

CHROMATO PHYLIA AND CHROMATOPHOBIA

> *“Nowhere perhaps is this mutual distrust more true than in the study of colour in the environment. This is where humans need-indeed crave- colour and where despite the lessons of history, he is deprived of it to an extent … it as almost dangerous. Scientists and artists make of colour a professional mystery. Architects-perhaps because they draw in black and white-are either frightened of it or ignore it. The drab results are around for all to see”*

Sir Hugh Casson’s 1976 quotation above based on his life long experience in both Art and Architecture has summarised the recent state of affairs particularly well.

More recently in 2009, John Outram has coined the phrase “Chromatic Deprivation” to illustrate the attitudes of designers of not using colour and David Batchelor wrote a book called “Chromatophobia” in response to the fears and suspicions in using colour.

THE FUTURE

> *“I am convinced that we are now experiencing a very important period in which architectural colour, now expressed in material and illumination rather than paint, is creating a new chromatic dialectic between form, space, structure and light.”*

The above statement in 2009 by Jean Philippe Lenclos, considered the foremost colourist in the world, is very revealing about what we are likely to expect in the future. His application of colour from industrial products to the environment and his books on the Colours of France, the Colours of Europe and “Coulers du Monde” have been very influential over the past forty five years, including our Oxford students since the 1970’s.

Over 40 years ago, in 1976, Tom Porter and the present writer, in editing “Colour for Architecture” brought together ideas of leading architectural colour practitioners for the first time with artists and psychologists to illustrate their work in colour and explain their research in easily understood language. In 2009 on revisiting “Colour for Architecture Today”, the story of colour research, theory and practice came with a new twist. New technologies and materials, colouring and lighting techniques have brought innovative ways bringing colour in our lives in both interior and exterior spaces. They have also brought about this dramatic shift from colour paint to new colour materials and colour lighting. They also brought concerns about the effect of modernism and post modernism on colour taste, the increasing usage of corporate colour for image and product and individualised identity and the migration of colour from interior to exterior places.

Mark Major writing in 2009 remembered his surprise when they were invited for an exhibition called “Any Colour You Like” in 2003 at the Building Centre in London, that their exhibit was the only one using lights rather than pigments for their exhibit. Compare this to Lenclos prediction of present day architecture. “The dimensions of the modern town or city make it difficult to introduce the natural elements which act as an important link and symbol of living nature. Certainly, colour is no remedy for this irreplaceable link but by its plastic and rhythmical powers of expression it is able to release a poetic dimension which complements the man- made environment. Here colour in material, structure, rhythm, contrast can be a new plastic language whose riches are offered to the city of tomorrow”. We are more likely to have a brighter and more colourful future. Some people may not like it and it will not be in everybody’s taste. For others it may take some time to get used to. Functional colour may be more prominent in public buildings, but there is plenty of scope to consider and apply aesthetic principles, not simply imitating nature and symbolism but in understanding the principles of synchronic and diachronic rhyme that exists in the relationship between the perceived elements.

The new materials, technologies and innovations referred above include Fabric Engineering, the engineering of the very clothes that we dress our buildings, are exemplified by the work of the outstanding British architect John Outram using colour concrete designs inlaid into rubber moulds and computer-driven printing into fabric. The young London practice of Niall McLouchlin, is deploying dichroic film material creating dramatic shifts in colour appearance.

Lighting architects, on the other hand, such as Jonathan Speirs and Mark Major from UK and John Nouvel in France, and artists get their inspiration from cutting edge technologies and materials in their projects from theatre and entertainment, LED, TFT, LCD and RGB systems. The designer could also look at other current successful collaborations between Jean Nouvel and the talented lighting artist Yann Kersale in their designs of the Lyons Opera House and Barcelona’s Agbar Tower.

It is particularly interesting and important for the architect, to consider carefully the wisdom and reflections of architects who have used colour and light consistently over the years. These reflections and personal philosophies are based both on experience and knowledge gained over time and sometimes tested by the feedback they received by both people and their fellow professionals

The winner of the Blueprint Award for Design 2014 went to Rogers Stirk Harbour & Partners nominated and voted by its readers. These buildings should be studied by the future designers. Previous Stirling prize winners included Richard Rogers’ Madrid Barajas Airport, Terminal 4, in 2006, noted for the use of graduated colour helping the passengers in identifying different areas of the terminal, as well as creating spectacular spaces

We are exposed constantly to the spectacular new sporting arenas for the Olympic games, from Athens in 2004 by Santiago Calatrava, the Beijing’s Bird Nest Stadium, the winter Olympics in 2018 to the forthcoming new Tottenham Hotspur Stadium in north London. These venues are lit in colour as we never experienced before incorporating cutting edge new lighting technologies creating both synchronic and diachronic rhyme in our perceptual experience. The opening and closing ceremonies, are not just spectacular but supremely colourful, all made possible in such a short period of time. The symbolic use of the colours of the French flag, Red, White and Blue, from the Eiffel Tower in Paris to the Sydney Opera House to show the world’s support to the French people after the Paris atrocities, reminds us vividly of this instant powerful tool in our disposal. International airports round the world are becoming colourful too. See the spectacular spaces for the Beijing International Airport, Barajas Airport Terminal 4, London Heathrow Terminal 5, Shenzhen International Airport, the BBC Scotland Headquarters, the London Arena, to name but a few.

EPILOQUE

Over the past few years and as we entered the new millennium, much has changed in cutting edge technologies and materials continuously emerging and allowing the practitioner in both interior and exterior architecture to be more creative and to experiment in colour and light than has been the case before. Based on the greater understanding of the perceptual and psycho-physiological effects of colour referred to earlier, the feedback from the users, and our exposure to more multi-sensory and innovative environments we can look forward to a more colourful, exciting and sustainable environment. Here again the future designer should know that "there is no truer colour responsive instrument to be found than man in all his variety and the best way to study colour is to use it." Nor he or she should fear that knowledge of the subject is going to block architectural creativity. As Sir Hugh put it then: "Luckily, no formula exists. Science can test, codify and inform. It cannot choose". We also have an additional factor here, in the ever increasing number of women entering architectural education with their stronger colour, aesthetic and literary interests contributing to more colour in the environment, not only because it is becoming more affordable and flexible in the new raw materials of colour but because it is part of experiencing life itself.

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Colour in the Built Environment

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Colour Sustainability and Authenticity in Portuguese Contemporary Architecture

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ABSTRACT

Beyond the consolidated city, in the peripheral and residual areas, it has been built collective dwelling of cooperative promotion, some awarded by their quality. These buildings are recent heritage and future legacy. Due to the present crisis, these buildings will face degradation. Given the impossibility of preserving everything, it is necessary to define colour authenticity criteria in the conservation and rehabilitation of the buildings. Also, considering that buildings are an expression of their time, most of them will not fulfil all the requirements of the present regulations to achieve sustainability without loss of their authenticity and cultural value. This study proposes a referential grid of colour authenticity criteria, based on buildings referenced by the old National Housing Institute in Portugal (today IHRU), which can be used to assess other buildings.

Keywords: *Colour, sustainability, authenticity criteria, contemporary architecture*

AUTHENTHICITY A DEFINITION

Authenticity means something specific and unique and different from “identical” which refers to universal, representing a class, reproduction, replica, copy, or reconstruction (Oxford Dictionary, 2nd Edition, OED2). While in many cases authenticity can relate to the “original creative source”, it is also a relative concept, and according to the modern value judgments, it can relate to historical continuity in the life of the heritage resource (Jokilehto, 1995). This includes different interventions in different periods of time, and the way that these have been integrated in the context of the whole (Tschudi-Madsen, 1985). The relative significance of each period in the whole should be established throughout a historical-critical process, in order to form the basis of treatments (Stovel, 1994). Authenticity can be understood as a condition of the heritage resource, and can be defined in artistic, historical and cultural dimensions of this resource. These dimensions can be seen in relation to aesthetic, structural and functional form of the object or site, in relation to its material technology, as well as in relation to its physical and sociocultural context (Jokilehto, 1995).

THE CULTURAL VALUE OF THE POST 1974 BUILDINGS

In the Portuguese architectural production there is a strong weight of the architecture made in the North of the country, which was internationalized at a European and worldwide level. The Oporto School and the Lisbon School took different paths, setting different architectonic cultures, which defined the cultural value of the cooperative housing made in the North and South of Portugal. Between 1976 and 1985 the Portuguese architecture and their actors experience some ostracism. The architectural assumptions developed since the 1950s were interrupted from 1976 onwards. Architects as Siza Vieira, Teotónio Pereira and Conceição Silva developed an architectural practice based on the affirmation of the authorship project. In the middle of the 1970s, in Portugal, the architectural planning focus on the internal resolution of what the *desire of forms* requires. The revivalism appears in several ways: in the recuperation of the roots of the Modern architecture, in the vernacularism or in the figurative historicism. In the Lisbon's School this return to the past is reflected on an evident historicism, and in the Oporto's School on a strict modern revivalism. The tendencies that took place in the 1980s are rooted in the second half of the 1970s. The Lisbon's School for the first time abandons the modernity and in the urban planning there is an increasing interest for the theorizations on the traditional city and the Italian work. A profusion of tendencies emerge: first, the recuperation of the history and of the khanniane monumentality; afterwards, in the path of the dissemination of Venturi's thesis, the tolerance for the illegal and immigrant construction, for the urban kitsch and the popular design, and for the classicism, which balances between the scenic character of some American works and the strong positions of the Brussels' School. The North of Portugal is strongly connected to Oporto's School mainly since the second half of the 1970s, when Siza Vieira grows as reference in the worldwide architecture, favouring the constitution of a consistent nucleus in Oporto's School, related to the Portuguese values and to the modernity of the architectural project of the 20th century. In the middle of the 1980s onwards, there was a crescendo of diverse tendencies and influences which were highly spread due to the increasing number of national and foreigner architectural magazines (Almeida, 1998; pp. 73-78). Currently the strong influence of the Oporto's School is still a reality. The use brick on the façades and the withe volumes became an image associated to Oporto School, while the colourful plastered façades become connected to Lisbon School. Throughout time a chromatic landscape of the country was built corresponding to different historical periods, identifiable in time, giving a specific identity to the buildings and to the places where they are implanted. The colour brought life to forms, volumes and surfaces either by the use of a simple paint, a pigment, or a building material. This chromatic identity of these buildings must be to preserved for the safeguard of their authenticity. Due to the present crisis, it is necessary to define colour authenticity criteria in the conservation and rehabilitation of these buildings.

HERITAGE, COLOURS, CONSERVATION AND REHABILITATION

Building materials and construction techniques help to build the identity of a building and define its typological characteristics. These aspects were defined in different international documents. The Venice Charter, 1964, defines as values to preserve, "the form and aspect of the buildings (interior and exterior) defined by their structure, volume, style, scale, building materials, decoration…". It remarks that "any aggression to these values would compromise their historical authenticity". Additionally, the Cracow Charter, 2000, states that Identity is a "collective reference which englobes the present values of a community and the authentic values of the past". Authenticity is the "sum of the substantial characteristics, historically proved, since the original state until the present situation, as a result of the various transformations which occurred in time". The original revetments and the architectonic surfaces are essential to the fruition of the building and to the reconstruction and critical reinterpretation of architectonic language. They are the material proof of the modification of architectonic language over time and testimony of the cultural history and technological level of a people. The conservation of old revetments is fundamental for the material and aesthetic authenticity of historical architecture and for the different expressions of identity. They contribute to the preservation of the *Genius Loci* given the strong rooting of the cultures of the places and their geological and geographical colour contexts, the revetments and the original surfaces. However, there are exceptional cases, such as Chelas, where the stigma associated to the population, to specific parts of the urban ensemble planned by architect Tomás Taveira (1975-1978) and the surrounding territory led to the demolition of parts of the original project and the modification of the colour palette, changing the perception of the place and of the built work, presently an historical urban tissue. These changes in problematic areas in colours (sometimes associated with the modification of parts of a building) raise questions regarding colour sustainability and authenticity, in the context of social demographics and geographical location, and how the colour palette can be maintained as the building goes apart from of the original project.

THE PLACE, PUBLIC SPACE AND THE RESIDENTIAL ENSEMBLES

The territory is a limited resource that must, therefore, be protected. Hence, the most sustainable option for the urban centre is the rehabilitation and renovation of the city, using the vacant spaces to implement new projects of urban connection, and to densify urban areas. In an urban area to be rehabilitated and preserved, the values of heritage, which make up the identity and memory of the place, must be analysed, protected and incentivized, and those include buildings, streets, squares, plazas, interiors of quarters, vegetation, topography and other elements that are relevant to the community. Different types of rehabilitation are made in the Portuguese recent heritage to improve the habitableness of the buildings and to link disconnected urban areas. To improve the relations of the building with the skyline and the ground, the rhythm of façades is changed, the area of the dwelling is enhanced, and new bodies for the common areas are developed, recommended or demanded, such as stairs or new elevators.

COLOUR AUTHENTICITY CRITERIA FOR THE COOPERATIVE HOUSING PRODUCTION

Beyond the consolidated city, in the peripheral and residual areas, it has been built collective dwelling of cooperative housing, some awarded by their quality. These buildings are recent heritage and future legacy. Due to the present crisis, these buildings will face degradation. Given the impossibility of preserving everything, it is necessary to define colour authenticity criteria in the conservation and rehabilitation of the buildings. Also, considering that buildings are an expression of their time, most of them will not fulfil all the requirements of the present regulations to achieve sustainability without loss of their authenticity and cultural value. This study proposes a referential grid of colour authenticity criteria, based on buildings referenced by the old National Housing Institute (INH) in Portugal (today IHRU), which can be used to assess other buildings.

These authenticity criteria, defined in Nara 1994 and refined in UNESCO Operational Guidelines since 2005 (namely, concept and design, materials and substance, spirit and feeling) will be used to analyse different case studies in Portugal. To establish these criteria six case studies are analysed. In Lisbon, two urban complexes of Justino Morais, in Caselas, INH honorable mentions in 1989 and 1992, and Zambujal's Integrated Plan of Carlos Carvalho, INH award 2004. This case contrast with the former by its degradation, lack of maintenance and alteration of the original drawing. In Oporto the urban complexes of Manuel Correia Fernandes, in Aldoar, and Pedro Ramalho and Luís Ramalho, in Matosinhos, are considered. The massive use of brick in these buildings contributes to a better preservation of the façades, though the graffiti is a common presence.

Figure 1: Caselas INH Honourable mention in 1992 of Justino Morais.

Finally, a colour study of Tomás Taveira for Chelas (Bairro do Condado, previously known as Zona J, 1975-1978). Colour is one of the most important elements of Tomás Taveira Architecture, very well known as one of the most famous architects based in Portugal. Looking through is Architecture he uses colour from the sixties to develop city life attracting people to shops façade in Cascais until big developments in housing and commercial centers in Olaias (1973-2005) and Amoreiras (Lisbon) and in big Stadiums of Football nowadays. Some of the Taveira´s projects are now considered historical buildings. They were built in the context of the Post Modern Architecture; their authenticity must be considered. They were made to dare to use colour. These case studies are representative of an architectonic culture that differs from the North to the South of Portugal.

DEPURATING AUTHENTHICITY CRITERIA

Taking in consideration the aspects from the analysis of the international documents were built the following authenticity criteria:

a) Design: Is the combination of elements that created the form, plan, space, structure and style of a property. It results from conscious decisions made during the original conception and planning of a property (or its significant alteration) and applies to activities as diverse as community planning, engineering, architecture and landscape architecture. Design includes such elements as organization of space, proportion, scale technology, ornamentation and materials.
b) Materials: Are the physical elements that were combined or deposited during a particular period of time and in a particular pattern configuration to form a historic property. The choice and combination of materials reveal preferences of those who created the

property and indicate the availability of particular type of materials and technologies; indigenous materials are often the focus of regional building traditions and thereby help define an area´s sense of time and place.

c) Workmanship: Is the physical evidence of crafts of a particular culture or people during any given period in history or prehistory. It is the evidence of artisans' labour and skill in constructing or altering a building, structure, object, or site. Workmanship can apply to a property as a whole or to its individual components. It can be expressed in vernacular methods of construction and plain finishes or in highly sophisticated configurations and ornamental detailing. It can be based on common traditions or innovative period techniques.

d) Setting: Is the physical environment of a historic property. Whereas location refers to the specific place where the property was built or an event occurred, setting refers to the character of the place in which the property played its historical role. It involves how, not just where, the property is situated and its relation to the surrounding features and open space.

e) Function/Use: Is the degree of continuity of the original or significant uses in a property. An historic area and its surroundings form a coherent whole including associated human activities and constructions; continuation of original or compatible uses minimizes negative impact on authenticity.

The referential grid of colour authenticity criteria is based on buildings referenced by the INH, which can be used to assess other buildings. The evaluation of the case studies is expressed in a scale which points out three levels of authenticity: low, 0% to 25%, medium, 25% to 50%, and high, 50% to 75%, considering that 100% is not achievable regarding historic places with an absolute level of authenticity. To test and externally validate the resulting colour authentic criteria it is used the Delphi method. Taking in consideration the different interdisciplinary views in Conservation and research materials, this research aims for a consensus for the concept of colour authenticity criteria.

CONCLUSION

In Portugal was built collective dwelling of cooperative promotion connected to Oporto and Lisbon Schools, some awarded by their quality. A chromatic landscape was built giving a specific identity to the buildings and to the places where they are implanted, which must be preserved for the safeguard of their authenticity. Due to the present crisis, it is necessary to define colour authenticity criteria in their conservation and rehabilitation. This study proposes a referential grid of colour authenticity criteria, based on buildings referenced by the INH, which can be used to assess other buildings.

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Historic Urban Landscape: construction of a methodology for integrated colour proposals

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ABSTRACT

This paper aims to determine the dimensions of colour in the Historic Urban Landscape and the extent to which these dimensions contribute to define new colour proposals for the public place. To achieve those goals, we claim that chromatic proposals are a multi-conceptual and evolutionary reading of the facade, city block facade and urban landscape. In order to support these chromatic proposals, three guidelines were taken into consideration and they are, as follows: colour morphology, colour typology and colour volumetry. That analysis provides information to characterise the colour of the urban landscape in its different dimensions allowing to conceive chromatic palettes' standards to be applied. Those standards support colour functionality within urban place identity encouraging a qualified user's experience.

Keywords: *Historic Urban Landscape; "A Cor da Ajuda"; Colour morphology; Colour typology; Colour volumetry*

INTRODUCTION

Since the mid-twentieth century, colour in the built environment has no longer a subject of certain constructive processes, materiality, dated styles and, or territorial specificity only. Industry and globalization created and disseminated endless colour pallets accessible to any consumer. This notion presents the colour debate, changes its role and its possibilities of use completely.

For the consolidated urban tissues several authors only consider the correspondence between ancient buildings and chromatic programs affiliated in particular characteristics of the place. Lancaster (1996: 82) argued *"the main argument for colour planning is that colour is there already"*. However, the city is not static, urban environment and people are constantly changing. So, colour as an urban phenomenon should not be read in isolation and/or in just one direction

(Codõner, 2002: 159). Particularly, the "historical urban landscape" (UNESCO: 2011) is a territory of cultural plurality, where different types and times converge, with heterogeneous materials and techniques. In such a living and complex context, that should be sustainable, humanized, accessible and comfortable, how should colour be perceived and used?

Through the case study of the "Calçada da Ajuda", this paper aims to define the criteria when choosing colour that fit in contemporary urban values, through a colour analysis methodology on an increasing scale: the facade, the city block facade and the urban landscape.

THEORY

The facade

Individuals react to sensory stimulation. But these stimuli should not be in excess (difficult to assimilate) neither in a reduced number (uninteresting). So, how to balance the vision sense and focus on what we really want to highlight?

As claimed by the Gestal theory, the whole is more than the sum of the parts. "*When viewing "whole", the mind no longer sees the individual parts, but rather only the aggregate of the whole along with the thoughts and feelings associated with that whole.*" (Koppec: 2012, 62). To a complete perception, the building façade has to be captured as a whole, and not underestimate signs of time and functions in order to preserve its constructive authenticity. Under analysis, the façade is composed by several elements that can be hierarchically prioritized to establish different levels of action. These levels aim to create focal points to attract sight and stabilize the visual stimuli.

In synthesis, the "colour morphology" results as an application of Gestal theory to unify facade perception of colour. Through establishing colour standards and, contrast restrictions and, secondary elements unified and outstanding primary materials, the stimuli are balanced and, simultaneously, the sense of coherence highlighted.

The city block façade

> "*Cities are dynamic organisms. There is not a single 'historic' city in the world that has retained its 'original' character: the concept is a moving target, destined to change with society itself*." (UNESCO, 2013: 24)

Figure 1: Photomontage of a city block façade in Calçada da Ajuda 201-219.

The historical city preservation on a static plane no longer fits into the current concepts of heritage. Thus, as far as colour is concerned, monochromatic or invariable colour schemes make no longer sense, especially in the complex and diversified Historic Urban Landscapes. But, how to limit the colour choice and chaos?

In the Historical Urban Landscape there are "groups" of buildings that share the same or similar chronological and typological identity (formal and structural) and, those characteristics are often associated with corresponding colour palettes and materials. This notion fits in the concept of "*colour loci*" advocated by Claudia Raimondo (1987) and Lenclos (1989), where the choice of colours derives from the historical and typological place context. Also, in Historical Urban Landscape recurrent materials are transversal to several construction times, which formalizes a local identity. The textures and reflections of these materials are elements of continuity that balance shapes and colours. Therefore, the challenge to colour de city block façade is to find a balance between heterogeneity and unity.

The “colour typology” concept recognizes heterogeneity among buildings due different construction times and, consequently the appliance of different materials associated construction process; however, repeated patterns establish a sense of identity.

The urban landscape

In a volumetric city, colour plans focused on the facades only are insufficient to dynamize the contemporary urban environment. Other elements such as backgrounds, flooring, furniture, nature and ephemeral elements, also have colour and power to convey legibility, orientation, and functionality.

The significance and symbol of colours is primarily determined by the relations between shapes, materials and colours: through contrasts, harmonies, polychromies, etc., that are produced stimuli, induced speeds and conditioned actions. Merrwein et al. (2007: 74) argued “(…) *it is possible to establish relationships between users, their activities, and the architectural space. Colour links these factors, thereby establishing an identity. It affects our body and mind deeply, influences our well-being and “psychological comfort”.*

On the "colour loci placemaking" concept, Cristina Boeri (2017) emphasizes the chromatic identity of the place and the ability of colour to create new identities. Colour has the power to make urban environment intelligible. Constant colour palettes can be used to distinguish functions, that gives user territorial control, increases its readability, organization and sense of unity. Also, environmental dominance and predictability interferes positively in the comfort and wellbeing of the user. Therefore, colour introduced as "wayfinding" (Gibson, 2009) measure is likewise an instrument for inclusion and identification (Gamito, 2011).

Within this framework, “colour volumetry” considers the tri-dimensional colours of urban space as a potential mechanism to offer legibility, orientation, and functionality.

EXPERIMENTAL

The facade

The façade colour proposals are based upon morphologic recognition, by pointing out original drawing and progression in time, finding in the current layout the guidelines to induct chromatic coherence.

The compositional, functional, material and chromatic analysis of the facade elements allows assimilate shapes, layouts and construction times. Through the drawing survey of each facade components (walls, frames, wedges, basements, etc.) different - primary and secondary - layers are distinguished and, the break points dissonant of the general building coherence.

According to this method, in Calçada da Ajuda ground floors changed materials were found, generally dissonant from the building’s original characteristics, which involve functions associated with commerce and catering. In the house’s upper floors most of the buildings facades have the original layout. However, almost all secondary elements (doors and windows, roof covers, advertising outdoors) had a carefree and uneven material and, colour treatment.

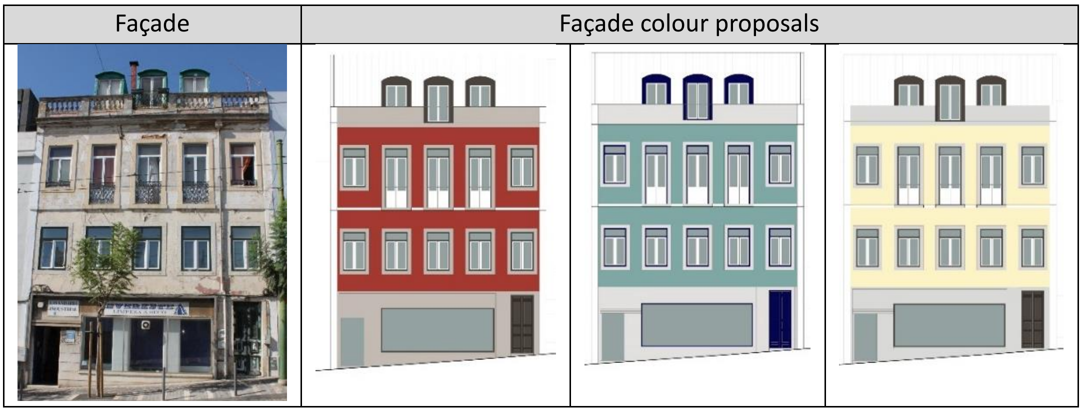

Figure 2: Façade colour proposals by "colour morphology" methodology.

The stimuli equilibrium proposed is based on the fields of psychology oriented towards the wellbeing of users through design. (Koppec, 2012)

On the one hand, colours and materials can be manipulated, unified or highlighted to enhance functional horizontality primary elements. Housing floors can be featured from ground and cover floors with unneutral colours to show the time passage and give contrasting visual focus on the main function of the building.

On the other hand, to give a sense of unity the secondary elements should be unified by the drawing, rhythm, material and colour. However, homogenizing is not about putting everything in same colour or material, but rather putting elements with the same characteristics within the same colour or material groups, creating patterns of repetition for similar elements, which help the associative reading and the sense of harmony.

The city block façade

First, the "colour typology" method analyses the period, the typology, the formal structure and the coating materials of each block building. Then these data are crossed with the colour survey to find connections that define the place identity.

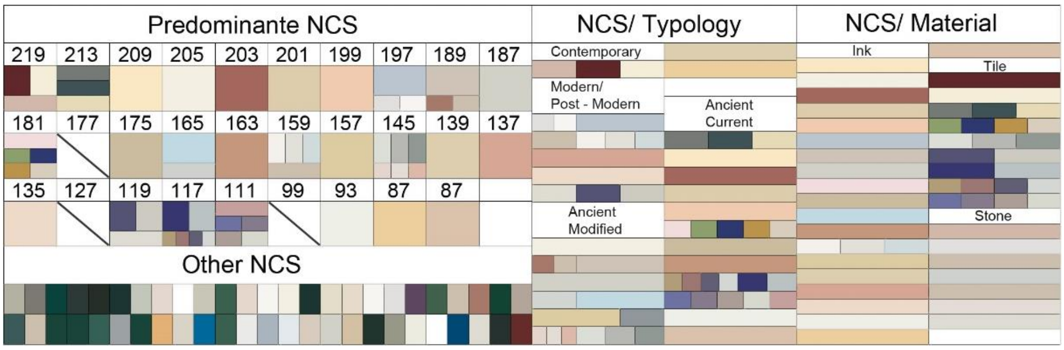

Figure 3: Colour survey in the city block façade.

In Historical Urban Landscape, the colour heterogeneity can be an identifying factor. Colours have space to stand out in their context. Denying this plurality and creating monochrome palettes are forms of aggression to the authenticity of the place. However, there is a sense of continuity given by the material, which defines a pattern of constant and coherent stimuli. In this context, very different materials would cause break points in block reading and, the break points (as a focus) should only be an option if they are intended to promote a better experience for the user.

The urban landscape

The “colour volumetry” starts from the colour survey and multidisciplinary analysis of all elements of the urban space, whether natural or artificial, perennial or ephemeral elements. Following the analysis of the intrinsic territorial characteristics and, the contextualized role of colour to generate good experiences and wellbeing.

Figure 4: Colour survey in the urban landscape.

This complex process of analysis is a work in progress. In the case study it was already possible to identify that there are few colour rules, which generates illegibility, lack of urban elements identification and disorientation in the pathways. A colour plan that qualifies the user experience in urban environment is a measure to take.

CONCLUSION

The Historic Urban Landscape is a complex territory built at various times where colour is all over the place. On a growing scale, the facades, the city block facades, and all other elements of the urban landscape are the dimensions where colour functions interfere.

This evolutive methodological approach depart from particular to general. Based on Gestal Theory, facade “colour morphology” search stimuli balance to provide comfort sense. On an intermediate scale, “colour typology” applied to block façades looks for patterns of repetition to improve the place identity. Finally, “colour volumetry” for the urban landscape involves a multidisciplinary and tri-dimensional approach to find urban readability, orientation and functional guidelines.

This methodology is considered as a contribution to find the urban chromatic palettes that qualify the user experience.

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S>C – Proposing a formula for Harmonic Urban Colour Composition

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ABSTRACT

As most cities, Trondheim has undergone considerable expansion in the last years, both in densification at its urban core and suburban expansion. Traditionally, the limited access to building materials and pigments naturally restricted the range of hues and nuances in the cityscape. Today, technological advances offer an almost unlimited choice of building materials and colour, and what traditionally used to regulate itself now requires some strategy if to achieve an overall colour gestalt. The paper will focus on the nuances in the range of hues in the city's colour palette, i.e. the relationship between the visually perceived blackness, whiteness and chromaticness of the identified nuances. Comparisons to colour registrations in other European indicates that, despite the differences, the results are generally valid, and can be of use in identifying the key aspects in the overall colour gestalt of a place or a city.

Keywords: *Colour in Architecture, Colour in Urban Space, Colour Analysis, Chromatic Composition, NCS*

INTRODUCTION

The paper presents the latest study in the ongoing project to identify a specific colour palette for the city of Trondheim, Norway, a city dating back over one thousand (1000) years and with a population of two hundred thousand (200.000) inhabitants. The identities of the majority of Norwegian towns and cities are foremost associated with painted façades in traditional hues of reds, yellows and greens, in combination with façades in nuances of light to medium dark neutral colours.

However, counter to the long tradition of chromatic variation, Norwegian architecture points to a dramatic change in the colour palette towards a perceived uniform, achromatic palette. The overall aim of the project was to identify a more specific colour palette for the city of Trondheim, examine the drivers behind the current drift towards an achromatic cityscape, and to develop a public colour guideline for the city.

As Lynch argues in *Image of the City* (1960), the overall colour gestalt is one of the most important aspects in the image of a city, and for how people perceive, inhabit and move around in the urban landscape. In *Urban design: Ornament and Decoration* (1999), Moughtin, Oc and Tiesdell points out that achieving a coherent colour gestalt of a city requires some strategic policy, which sets the basis for the colour agenda. In his paper *Strategies in Colour Choice for Architectural Built Environment* (2017), author Zennaro is seconding this, adding that the designer needs a dedicated strategy, different from case to case, specific to each place.

Traditionally, the limited access to building materials, binders and pigments naturally restricted the range of hues and nuances in the cityscape. The colours were generally variations of the same hues and nuances, managed in different ways according to style and fashion. Today, technological advances offers an almost unlimited choice of building materials and colour, of international origin and unspecific to a particular place, and the decision is often in the hands of more unexperienced consumers. Historical styles lasting decades has evolved into short-lived trends. What traditionally used to regulate itself now requires some strategies if to achieve an overall colour gestalt specific to a place.

Figure 1. Collage of facades in Trondheim city centre, from the vernacular wooden housing, the iconic waterfront warehouses and the rendered jugend buildings, to some of the more modern commercial buildings.

This project is based on registrations of the nominal façade in Trondheim, with a particular focus on the city centre with traditional façade materials of painted timber cladding and rendering. However, the full registration material includes façades in the more modern, commonly used materials such as brick and façade panels.

Analyses of the registered colours of the citys façades showes a very clear tendency for the use of specific hues and nuances (figure 1, right), thus providing a contextual base for a strategy in upholding the city's overall colour gestalt. The paper will focus on the nuances in the range of hues in the city's colour palette, i.e. the relationship between the visually perceived blackness, whiteness and chromaticness of the nuances.

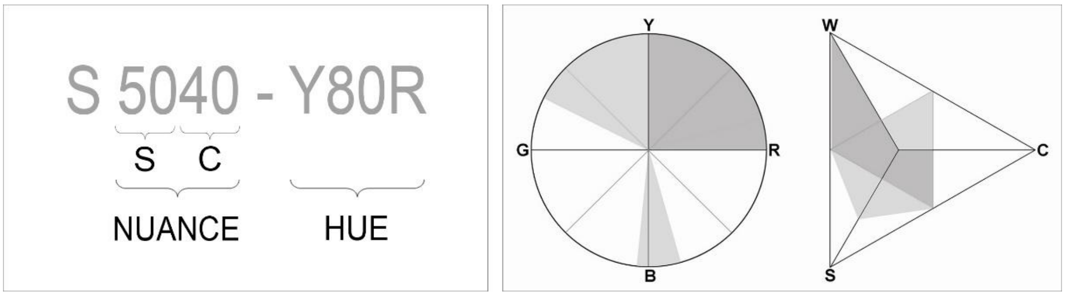

Figure 2. Left: Illustration of what the NCS notation. Right: Diagram of the hues and nuances characteristic for Trondheim[1]. The darker sections shows the most used hues and nuances in the cityscape, and the lighter sections show the more rare hues and nuances - to be used with care and purpose.

THEORY

NCS has been Norwegian Standard since 1984, and the colour reference system used in the registrations and in the analysis of the material to identify typical hues and nuances for Trondheim. The NCS system is based on how we perceive colours visually, and the notation describes how the chromatic elementary colours, yellow (Y), red (R), blue (B) and green (G), relates to the achromatic elementary colours white (W) and black (S). The nuance describes the relationship each hues chromaticness (C) relates to blackness (S) and whiteness (W). The first two numbers in the NCS notation describes the nuances resembled blackness, the next two describes the resembled chromaticness, and the resembled whiteness makes up the perceived nuance; S + C + W = 100% nuance. For example (see figure 1, left), if the blackness of a nuance is 50% and the chromaticness is 40%, the whiteness must be 10%.

> *"Experience teaches that certain combinations of different colours are pleasing, other unpleasant or indifferent. The questions arises, what determines the effect? The answer is: Those colours are pleasing among which some regular, i.e. orderly, relationship obtains. Lacking this, the effect will be displeasing or indifferent. Groups of colour whose effect is pleasing, we call harmonious. So we can set up the postulate: Harmony = Order." Wilhelm Ostwald*

In the NCS description of *Colour Similarities and Harmonies,* the system offers several opportunities of colour combinations and harmonies, such as similarities in hue, nuance, blackness, chromaticness, whiteness, lightness or saturation. In the analyses of the colour registrations in the Trondheim palette, we have identified the typical hues and nuances for the city. However, as the colour contrasts are in a relatively wide variation of hue and nuances, what defines as the most significant similarity that contributes to Trondheim's overall harmonious appearance?

EXPERIMENTAL

In Trondheim, the registrations of the nominal façade colours of the two thousand (2000) buildings has been gathered over four years, representing the depth and width of the city's colour gestalt. In the registrations, we used the NCS index and NCS Colour scanners to find the nearest Standard NCS notations. The notations show the approximate NCS notation for the colour of the façade, i.e. the inherent colour or the building material or the painted surface, and not as they are perceived.

[1] The diagram has been updated from previous studies in 2016 to include rare blue hues, darker nuances of red and green and the more chromatic yellow, as they are important to the overall colour variation of the city.

As all colour reference systems is restricted to approximately one to two thousands (1000 – 2000) of hues and nuances, the notations will not necessarily show the exact colour match. However, as the aim was to identify the main colour attributes of the hues and nuances, the notations provide sufficient information for the purpose. This paper focus on the main façade colour, i.e. colours of the cladding material of painted wood, rendered plaster, stone, brick and façade panels, excluding the colours of building details and articulation.

We have used the same method to register facades in other European cities, where the registrations represent between two to three hundred (200 – 300) buildings in the city centre. The registrations was conducted in the same timeframe as Trondheim, and the building materials in the other cities was generally found to be rendered plaster, brick and stone.

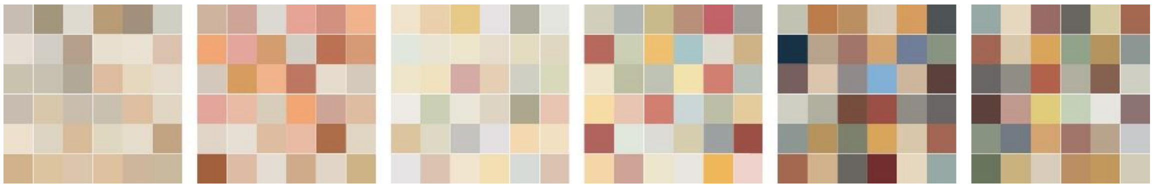

Figure 2: From left, illustration of the overall colour palette for city centre of Paris, Rome, Vienna, Graz, Copenhagen and Trondheim. The colours show the range of the nominal colours of the façades registered, given in the nearest NCS notations.

RESULTS AND DISCUSSION

The analysis of the Trondheim palette has previously identified the use of specific hues and nuances (figure 1), with hues ranging from G30Y - R, and nuances generally between 0502 – 5040 – 6020. Specifically, the nuance pattern are slightly different in each hue, with a wider range of yellows than reds, and an even more restricted use of greens. Blue hues are rare, ranging between R80B – B10G, in nuances typically between 2502 – 6020. An overall rule is maximum chromaticness is 50%, and minimum chromaticness is 1%.

Further analysis of the nuances shows a clear relationship between the blackness (S), chromaticness (C) and whiteness (W), and that, regardless of the amount of whiteness, the blackness should be higher than the chromaticness, but for a few hues in yellow and red. The exception of the rule is within the hue range Y10R to Y30R, and a very particular hue around Y80R, i.e. 2040-Y10R, 2020-Y20R and 3040-Y30R, and 4050-Y80R. We propose the postulate that for Trondheim, the most important strategy for a harmonious colour gestalt is the formula S>C.

City	Typical hues	Typical nuances	Typical S + C	Rare deviation from rule
Paris	Y20R - Y60R	1005 - 3020	S>C	Nuances 4010-Y10R to -Y30R
Rome	Y20R – Y80R	0804 - 4030	S>C	Nuances S<C and S=C Blue hues: C = 1–5%
Vienna	G60Y – Y90R	0502 - 3010	S>C	Red hues: Y70R – Y90R Blue hues: C = 1–2%
Graz	G10Y – R	0502 - 4040	-	Blue hues: C = 1–2%
Copenhagen	G - R	1002 - 7010	S>C	Blue hues: C = 1–30%
Trondheim	G30Y - R	0502 - 6020	S>C	Nuances S<C and S=C Blue hues: C = 1–20%

Table 1: Overview over the most typical hues and nuances of the main façade colour given as the approximate, nearest standard NCS notation.

In the analysis of other cities in Europe, we have found a similar pattern (Figure 2 and Table 1), but for Graz in Austria. Paris has the most restricted range of hues and nuances, and Copenhagen the most varied. Colours in Paris, Vienna and, partly, Rome predominates in the whiteness, while Graz, Copenhagen and Trondheim has a wider range in the nuance. All cities share the overall rule is that maximum chromaticness is 50%, and that minimum chromaticness is 1%. Apart from Graz, the most typical nuance similarity is that the blackness is generally higher than the chromaticness.

However, when visiting the city centre of Graz, most visitors would probably not feel that the colour scheme is displeasing or disharmonious. In previous analysis of the registrations, we have found links between specific hues and nuances to buildings material, paint properties, texture, volume and building details. This aspect of the project is still unfinished, but suggests that a homogenous building typology of a street, area or place allows for more variation in colour. Of the six cities analysed, Graz has the most homogeneous building typology, and it is likely that the similarities in the overall gestalt lies in likeness in building size, shape, materials and textures. Trondheim has the least homogenous building typology, brought together by colour similarity. However, further research is needed to give conclusive results.

CONCLUSION

In the search for design strategies to strengthen the sense of place, colour is significant. We have found that most cities visited have a typical colour signature in their hues and nuances. The hues and nuances are generally not that different, but the range varies. Despite the differences, comparisons between the registrations in the selected cities gives indications that the results are generally valid for other cities, and can be of use in identifying the key aspects in the overall colour gestalt of a place or a city.

ACKNOWLEDGEMENTS

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The Colours of Alvar Aalto

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ABSTRACT
A great number of books and articles have been written about the architecture and furniture designs of Alvar Aalto (1898–1976), but very few of them mention anything about his use of colours. This paper focuses on how Alvar Aalto was influenced in his use of colours by the avant-garde and modern art and design of his time. Colour is an integral element of Aalto's architecture, especially in his lesser-known early works and in the world-famous functionalist buildings of the late 1920s and early 1930s. Aalto was not only an architect, but also a designer of innovative furniture, lamps and glassware. Colour played a major role in also these designs.

Keywords: *Alvar Aalto, architecture, design, colours*

INTRODUCTION
'Humanist modernism' or 'humanist rationalism' are the epithets most often associated with Alvar Aalto's architecture and design. The organic, nature-related forms and free-flowing spaces of his building as well as his human-centred design philosophy are the principle reasons behind this interpretation. (See for example Schildt 1986). Thus, Aalto's works have been appraised through his handling of form and function as well as through his effort to harness rationalism and standardisation in the service of better living. His colours have received little or no attention, although they are an inseparable part of these efforts. Recent and ongoing research and conservation reveals that many of Aalto's early buildings were originally much more colourful than has been known hitherto (Riksman 2015). In his better-known mature works Aalto showed a highly developed sense of hapticity and atmosphere. In these works, Aalto avoided strong space-defining colours in favour of nature-inspired textures and muted colours of wood, stone, brick and ceramic tiling. In many of the interiors these subdued tones were offset and enlivened by Aalto's furniture, whose vibrant colours were inspired my modern art.

AALTO FURNITURE AND THE COLOURS OF MODERNISM

From the very beginning of his career in the early 1920s Alvar Aalto travelled frequently abroad. On these trips Aalto formed lifelong friendships with some of the most avant-garde artists his day. These included Lazlo Moholy-Nagy, Fernand Léger and Alexander Calder. Their influence on Aalto's colours and forms was as important, if not more so than that of the often referred-to Finnish nature.

In 1937 Aino and Alvar Aalto, Nils Gustav Hahl and Maire Gullichsen founded the furniture and interior design company Ab Artek Oy, primarily to promote and distribute Aalto's furniture internationally. Most of Aalto's furniture and their colours were created in context with his architectural projects. While the surfaces of his mature and later buildings become more and more neutral and material-based, much of the furniture retained its vibrant accent-like colours, which Aalto had favoured already in the 1020s. A hallmark of Aalto's furniture is its modular construction, which allows the creation of a great variety of models from simple elements. The pre-Artek Aalto furniture had been manufactured in small quantities for the home market or as one-offs for specific projects. The wooden chairs and stools came in combinations of all kinds of colours, which disappeared soon after Artek was founded. The early stools and chairs were also sold in plain unvarnished wood; the customer could then paint them any colour they wished! With growing production volumes, came the need to standardise not only the furniture's construction and models, but also their colours. The scale became reduced to a simple combination of natural pale woods (birch or sometimes ash or beech) with tops in black, white and a few primary colours, usually red, yellow, blue or green. Thus, the modular principle was applied to also the colours of the furniture. While the modular structures of Aalto's furniture continued to allow a certain degree of variations of their colour combinations, the new methods of mass production meant the birth of Aalto's standard furniture and standard colours.

The one person who had the greatest influence on the forms and colours of Aalto's early functionalist buildings was undoubtedly Le Corbusier. The similarities are apparent in the Viipuri library, The *Turun Sanomat* building and in Aalto's international breakthrough work, the Paimio Tuberculosis Sanatorium. Aalto employed, especially in the latter two, a colour scale which strongly resembled Le Corbusier's famous *Claviers de couleurs*.

From the late 1930s onwards, Aalto and le Corbusier went their separate ways, at least as far colour is concerned. Le Corbusier's architecture became more and more sculptural and polychromatic, whereas Aalto emphasized hapticity, light and atmosphere. Thus, the tone of the interiors of Aalto's mature buildings was relatively neutral, and polychromatic accents were introduced in the form of furniture, interior decoration and artworks. This allowed maximum flexibility and a modular approach to combining colours.

SPACES, COLOURS AND ATMOSPHERES

The colours of Alvar Aalto's architecture can be divided into three stylistic periods: 1) the richly polychromatic Nordic Neoclassicism and Art Deco-influenced buildings of the early and mid-1920s, 2) the mainly white exteriors and richly-coloured painted interiors of the Functionalist buildings of the late '20s and early '30, 3) the material-based colouring of the post-World War II period. This last period included the use of coloured ceramic tiles and in many cases a deep midnight blue surfaces in ceramic tiling or wood, bringing a noble chord to the otherwise neutral palette of white, grey and wood colours.

The Workers' Club in Jyväskylä (1924) and the Defense Corps Building in Seinäjoki (1924) are among the few relatively well-preserved Aalto buildings from his Neoclassical period. Their colouration is entirely different from all subsequent works. During the 1920s Aalto drew ideas and influences from his Swedish contemporaries and friends Gunnar Asplund and Sven Markelius. The colour scheme of the interior of Aalto's Jyväskylä Workers' Club, restored in 2008, is striking: the ground floor entrance hall has pale primrose walls with black skirting boards; black stairs lead past two decorative urns in vivid blue, red and gold. The first-floor foyer is a symphony of Pompeian red, bright blue, off-white and greyish black. Ongoing research and colour restoration on Aalto's buildings of the same period shows that they had equally rich colour schemes.

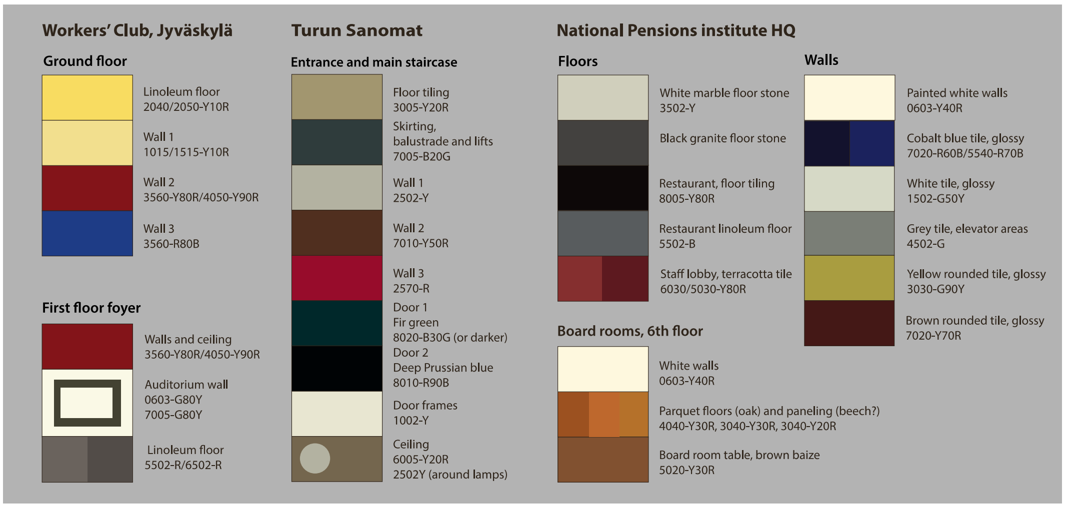

Figure 1. Interior colours in three buildings by Alvar Aalto (all in Finland). The NCS codes refer to the nearest available NCS standard colour and are given without the NCS S prefix. All measurements by the author, August 2015.

THE LOST COLOURS OF MODERNISM

The *Turun Sanomat* Newspaper head office and printing works in Turku, Finland (1928–30) is a fully-fledged example of Le Corbusier -inspired functionalism. The extant interior colours offer a rare glimpse of the kind of colours that were used in functionalist buildings of the era, and which are now lost in most similar buildings. Many of the *Turun Sanomat* office and printing works spaces have been altered, but the hallways and staircases are relatively well preserved and the colours have been recently restored to what is presumably very close to the original. Nearly all surfaces are painted with full-gloss lacquer paint and the colours are in elegant tones of crimson, dark fir green, chocolate, and warm grey (Figure 1, above).

In 1928 Alvar Aalto travelled to Paris where he was shown Le Corbusier's studio and other buildings. However, Aalto did not meet Le Corbusier who happened to be in Moscow at the time (Schildt 1986, p.56). Aalto finally met Le Corbusier at the CIAM (*Congrès Internationaux d'Architecture Moderne*) conference of 1929. The records do not say whether Aalto discussed (despite the fact that he knew no French) architectural colour with Le Corbusier at this meeting. At the next CIAM meeting in 1933 in Athens Aalto kept company mainly with Le Corbusier. Nils-Gustav Hahl, who was also present, reported later how the two commented Fernand Léger's lecture on architectural colour: "…both of them typically considered only the physiological effect colours have on people, and almost wholly disregarded their aesthetic qualities". (Schildt 1986, p.95). In any case, although the *Turun Sanomat* was completed in 1930, the colours in the halls and staircases seem as if taken straight from the 1931 colour keyboard.

Le Corbusier had written extensively on the subject already in 1928 in an article with the title *Polychromie architecturale*. It remained, however, unpublished until 1997. Two years after writing the article Le Corbusier published his first collection of *Claviers de couleurs* for the Salubra wallpaper company. The trade literature of the 1931 *Clavier de couleur* describes it as "…a system which makes it possible to establish a strictly architectural polychromy in the modern dwelling, one in accordance with nature and with the deep needs of each person." (Menin & Samuel 2004, p.57) This idea would surely have resonated well with Aalto.

Immediately after completing Turun Sanomat, Aalto began work on his major international breakthrough, the Paimio Tuberculosis Sanatorium (1929-33). There are Corbusier-influences in Paimio, too. In all his architecture Aalto used space, materials, colours and light to create ambiences for physical and psychological needs, to comfort and uplift the user. Nowhere is this more evident than in Paimio. Every surface and colour is carefully designed with the health and wellbeing of the patients in mind. Although many of the original colours are still visible in the Paimio Sanatorium, according to the recently published research by Elina Riksman, Paimio was originally much more richly coloured than its present-day appearance indicates. (Riksman 2015).

JAPANESE INFLUENCES

As Juhani Pallasmaa has pointed out, Aalto's handling of space and materials shows clear influences of Japanese culture and architecture (Pallasmaa 1998, p.98). His shift from paint and pigment colours to material colours may also have been prompted by Japanese influences. Aalto, who never visited Japan, acknowledged his admiration for the ethos of traditional Japanese interior design in an address to the Swedish Craft Society in 1935 (Schildt 1997, p.271). The interiors of Villa Mairea in Noormarkku (1938–39), the Experimental House in Muuratsalo (1952–53), Maison Louis Carré in Bazoches-sur-Guyonne (1959) and the Aaltos' own home on Riihitie in Helsinki (1935–38) have an atmosphere that resembles that of traditional Japanese houses. The interior walls are off-white or covered with plain fabric or wood. Strong chromatic colours are reserved mainly for details, such as upholstery and curtains or decorative objects.

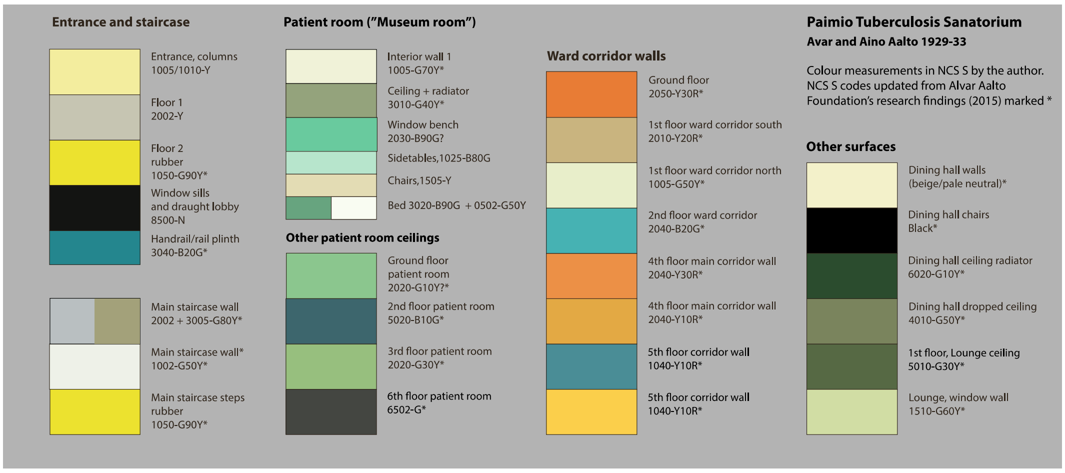

Figure 2. Interior colours of the Paimio Tuberculosis Sanatorium. Aalto engaged the master decorator Eino Kauria to assist him with the colour design. Bright canary yellow linoleum and rubber was used in the flooring and skirtings of the main entrance hall and staircase. The patient rooms were painted with soft green tones to give visual relief for the recumbent patients. Full gloss lacquer paint was used on many of the hospital surfaces. The NCS-codes marked with * have been updated from the 2015 research by Elina Riksman of the Alvar Aalto Foundation.

Aalto's exteriors of this period are often either white plaster, brick, oxidized copper or bronze cladding. The materials were chosen as much for their durability as for their visual qualities. In Villa Mairea there are wooden and natural stone elements that chromatically further integrate the house with the surrounding forest landscape. This interconnection of natural and man-made environments continues indoors in the wood and stone details, the houseplants and the free rhythms of the clusters of wooden pillars. With the nature-inspired, restrained colour palette and especially through his masterly handling of natural and artificial light, Aalto created interiors that allow flexibility and harmonious combination of brightly colour details and accents with furnishing and textiles.

CERAMIC TILES AND THE SIGNATURE BLUE

One exception in the later Aalto's restrained architectural palette is the use of deep midnight blue in various materials – most memorably in the rod-shaped cobalt blue ceramic tiles that he used in many of his civic buildings. This blue first appeared on the background wall to the outdoor fireplace in Villa Mairea, then again on the exterior wall of the patio in the Aalto's summer residence or Experimental House in Muuratsalo. From there on this 'signature blue' appeared in one form or another in almost every civic building designed by Aalto.

Alvar Aalto created an exceptional variety and richness of colours, materials and textures in the National Pensions Institute Headquarters in Helsinki (1952–57). Aalto achieved this chiefly with specially manufactured, rod-shaped, flat and round ceramic tiles. Their colours were cobalt blue, brown, mustard yellow, off-white and grey. The off-white and grey tiles have a satin glaze, while the all the rest have a full-gloss glaze to them. The variation of colours, profiles and finishes creates a rich optical and haptic experience, reminiscent of kinetic sculpture and painting.

CONCLUSIONS AND DISCUSSION

Aalto's colours were influenced by his early and lifelong contacts with some of the most radical and famous artists of the modernist period. Aalto's radically modern furniture colours were probably inspired by the vibrant "pure palette" of the early abstract painters and sculptors, such as Fernand Léger and Alexander Calder. Le Corbusier probably influenced not only the structure and forms of Aalto's early Functionalist buildings, but also their interior colours, which are now being rediscovered in their full richness. How direct the influence of Le Corbusier's *Polychromie architecturale* was on Aalto is a matter of further investigation. Colours were an inseparable part of Aalto's quest to create comfort and welcoming atmospheres and to serve the "biological needs" of the ordinary man and woman in the street.

ACKNOWLEDGEMENTS

I am indebted to Professor Juhani Pallasmaa for the idea of embarking on this research and for his support and encouragement. I would also like to thank The Alvar Aalto Foundation and curators Katariina Pakoma and Timo Riekko of the Alvar Aalto Museum in Jyväskylä, Finland for their kind assistance.

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The Scales of Colour Perception in Architecture

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ABSTRACT

In pursuit of a more objective approach for making colour decisions for buildings, the aim of this study is to introduce the concept of scales of perception of colour in architecture. The paper starts with an introduction of Lima, where heterogeneity in styles allows a wide spectrum of colour possibilities. The concepts of distance and scale have been revised. Six scales, based on distances of perception, defined in general terms: geographical, broad context, immediate context, architectural, detail and material. In order to test the proposal, four examples from Lima city, in which colour relates to human scale, have been summarized. The discussion points out the connections amongst the scales of perception and the effects of colour on human scale, as observed in the examples.

Keywords: *architectural colour, context, human scale, perception, scale*

INTRODUCTION

The purpose of this study is to consolidate a stage in the process of analysing and designing architectural colours. A more objective approach in colour decisions will lead to better results as regards comfort, environment and aesthetic aspects.

The scales of colour perception in architecture proposed in this paper were pinpointed after having worked for 30 years in building colour research and design in Lima, where paint has been the conventional finish for exteriors since Colonial times. In the actual context of Lima, improvement as a result of renovating paint is expected. With more than ten million inhabitants, Lima is located on the Pacific coast, at latitude 12° south of the Equator. It is characterized by mild temperatures, high humidity, absence of rain and overcast sky. The colours recommended for visual comfort in Lima according to my architecture thesis (1987) and to the paper *Climate and Coloured Walls, in search of Visual Comfort* (AIC 9th Congress, 2001), are those of medium-saturation and low brightness, as these provide rest for the eye and are still recognizable in humid conditions.

The visual effect of coloured buildings is subject to the viewing distance and other conditionings. When observing a building, height and horizontal extension determine the convenient viewing angle. According to conventions, the viewing angle for an individual construction is 27° above the horizon, and it decreases to 18°, for a set of buildings, though parameters as such would depend on each specific case (Ashihara, 1981). Furthermore, perception often involves displacement, so speed and duration of the experience must be taken into account. Movement links the experience of perception as when flying over a landscape or approaching a building (Burga, 1987). As we get closer to an object, we pass from the sense of vision to the sense of touch. Architectural photography shows compositions that go from aerial views to the minutiae of materials. Powers of Ten, a 1977 production by Ray and Charles Eames, makes the understanding of space clear and explicit through a sequence of photographic images in colour, by conveying impressions of relative distance in shifts of scale.

Initially it was not intended to specify measurements for the scales of perception for this study, but it proofed orderly to make the distance ranges for each scale coincide with powers of ten: from 10cm (10^{-1}) for the material scale to a distance ranging from 10km (10^4) for the geographical scale. The architectural scale is at the core, with an observation distance of 10m (10^1). The intermediate scales of detail, context and broad context complement the sequence, from 1m (10^0), 100m (10^2) and 1000m (10^3), respectively.

Scale of Perception	**Perceived objects**	**Referencial distance**
Geographical	landscape features and buildings/settlements	10,000 m
Broad Context	avenues/squares/skylines/built backgrounds	1,000 m
Immediate Context	streets/neighbouring buildings/rows of houses	100 m
Architectural	houses/buildings/ building complexes	10 m
Detail	stylistic elements/metal, glass, wood, stone	1 m
Material	exposed construction materials/cladding and finishing materials/paint and coatings	.10 m

Table 1: Scales of perception, perceived objects and referential distances proposed for each scale.

SCALES OF COLOUR PERCEPTION IN ARCHITECTURE

The proportions of the human body have been subject of examination by Vitruvious, Alberti and Leonardo. In Le Modulor (1948), Le Corbusier introduced a system for dimensioning space according to the human scale. Among its many connotations, the word scale is a ratio or relation of proportions, as the human scale relates “the size of a building element or space to the dimensions and proportions of the human body” (Ching, 1979, p. 326). Scale also refers to the size of an object: a grand scale. In physics, geography and astronomy the spatial scale is an approximation of the extent of area to be studied. The concept of scale in this paper is closer to this last definition although some others interpretations will be brought up. A scale of perception would be a stage in a sequence in which the distance from viewer to object is increased or decreased progressively.

The scales of colour perception in architecture proposed in this study are related to specific circumstances of observation. Data about cities, landscapes and settlements provided by colour at the geographical scale is abundant. While remote colour functions as indicator of landscape and cosmic characteristics, the colours of buildings as light-reflecting objects, at 1,000 to 10,000 meters of distance, give information about population, climate, history, culture and environment.

The broad context scale, at a distance range of 100 to 1,000 meters, was pointed out for cases were buildings are seen from specific viewpoints. These include perspectives, wide avenues and squares, skylines and buildings acting as background. The immediate context scale, at a distance range of 10 to 100 meters, is defined by the position of the viewer within a delimited area. This could be a sequence of houses in frontal view or a street perspective. The architecture may be similar in style, height and function, and also have a common background, trees and street furnishings.

The architectural scale embodies the building as a whole, composed of volumes, spaces and constituent elements from openings and voids to details, organized as a unit. This scale of perception includes façades, and buildings with space around them, which may acquire a sculptural quality. The more advantageous position to observe a building will depend on its dimensions. In photography it is recommended that the camera is at a distance between one and three times the height of the building (Schulz, 1980). In practice this would depend on the availability of foreground. For its size, the scale of an architectural object can be considered monumental.

Figure 1: The scales: geographical, broad and immediate context, architectural, detail and material.

The detail scale may be observed at a slower pace. Architectural features of varied sizes and shapes act as references to human scale. Cornices, friezes, mouldings, windows frames, railings and others which have a three-dimensional or textural quality are in this category. Fineness of craft in ornaments cast on the façade, and wood, steel and stone components, are appreciated from this observation position.

The scale of material is perceived from distances as short as 10 centimetres. The quality of the substance awakens the haptic sense. Jean Philippe Lenclos (1990) attributes the appearance of veracity of a material to the type of coating, as it tends to have a more natural feel if it can breathe through the surface. At this scale it is possible to evoke the materials of the place with especially prepared tints, associated to the soil. With texture the possibilities of finishes for vertical surfaces are multiplied, as colour perception varies according to relief, grain and porosity. Textured surfaces are perceived darker in comparison to flat surfaces, in which light colours accuse the smallest unevenness. As distance increases, the perception of texture is reduced, though a secondary texture or pattern might appear (Ashihara, 1981). Lighting intensity and orientation are determinant of the effects of colour at the material scale, and transcend to all other scales.

SELECTION OF EXAMPLES

The examples gathered from various points in Lima, in overcast conditions, have been observed from different scales of perception with the purpose of identifying effects of colour in relation to the human scale.

The outskirts of Lima towards the south have been populated by migrants since two decades ago. New settlements have invaded the hillsides with simple constructions made of brick. These have been differentiated by colours from the available paint catalogues, for protecting, raising status and personalizing the houses. A variety of medium-intensity and bright colours results in a chromatic pattern that has been replicated in the neighbouring communities becoming a continuum for kilometres, for there is a succession of settlements next to each other. There are some interesting points to make about the impact of this initiative: the integration at a geographical scale and the monotony of polychromy. In the immediate context unfinished brick walls still appear dominant, and the effect of differentiation is not as clear as when seen from a distance.

In wide avenues and expressways, buildings perceived from the car at distances of 1 to 5 kilometres form perspectives that include high-rise buildings. These usually have glazed fronts and lateral walls in neutral colours. At the sides of the road the urban equipment is yellow and blue, for metal posts and signs panels, respectively. The impression of the skyline is stronger than the vision at eye-level, as the lower view is usually blocked by cars. At a higher level, a few coloured elements on building tops stand out in the distance. Every bright colour counts for breaking the monotony. Orange, red and purple acquire importance for orientation of the driver, acting as a reference of distance.

Buildings of dissimilar profiles next to each other are recurrent in the consolidated districts of Lima. Older constructions, usually two-stories high, are often painted in colours that contrast with the plain exteriors of higher buildings. These are mostly glazed, with walls in exposed concrete, or painted in white and neutral colours. The use of chromatic colours in neo-colonial and eclectic architecture, adds to the character of the streets, favouring the human scale especially where building blocks of simple appearance dominate the scene.

In many districts of Lima it is typical to find constructions similar in style in rows of four or six units coloured in hue gradations. These are complemented by details in neutral and analogous colours. Differentiation of building fronts by colour favours the human scale. In a careless manner, the use of contrasting and saturated colours is common practice in commercial and low income areas. The effect may strike as disharmonious at this scale, where the aesthetic aspect plays an important role for the pedestrian.

Figure 2: Geographical polychromy, bright colours on building tops, difference by height and colour treatment, chromatic gradation.

THE ROLE OF COLOUR AT THE DIFFERENT SCALES OF PERCEPTION

In looking for examples of buildings with colour effects that contribute to the human scale, it was observed that the natural movement of the user in outdoor space oscillates among various scales of perception. There are specific moments when colour information is useful and necessary for orientation and confirmation of status (time of day, traffic, position). This suggests that the level of awareness varies according to the interest of the user and to his effort to recognize information about the space.

The examples gathered for this paper acknowledge orientation and identification as functions of colour in large spaces. Even small elements in bright colours operate as reference points for direction and distance amongst large non-chromatic surfaces. The prevalence of neutral and non-coloured surfaces, allows colour to accomplish different roles, for colour-cluttered areas overload the environment with disorganized information.

In open spaces large coloured surfaces serve to grant or emphasize building identity. These may also simplify spatial complexity, contributing to orientation, provided that the assignment of colour responds to an order.

In secluded spaces colours of medium and high saturation have a different effect than in open space. The information is processed according to the scale of perception. At the geographical scale colour works for identification and appreciation. In the broad context colour functions for identification and orientation. While, in the immediate context and architectural scales, colour has a psychological or symbolic value. The quotidian experience at the lower scales has an impact on the user's behaviour and wellbeing, and adds to the sense of belonging.

The material scale is comfortable for the artist and the painter. It may become familiar, as exposure and experience sensitizes the user, even if he is unaware of paint materials and textural differences. On the practical side, decisions taken at this level transcend to the bigger picture, surpassing the maintenance aspect.

Scale of Perception	Function of colour	Dimension adjustment
Geographical	appreciation/identification/integration	hue/lightness
Broad Context	identification/orientation/rhythm	neutral/hue/brightness
Immediate Context	integration/differentiation/familiarity	hue/saturation
Architectural	enhancement/psychological	hue/nuance
Detail	enhancement/integration	hue/nuance
Material	practical/aesthetic	hue/nuance

Table 2: Function of colour and dimension adjustment for each scale of perception.

CONCLUSIONS

Spaces and buildings work within systems that rely on colour vision for orientation and identity. Architectural colour accomplishes different functions that contribute to the human scale, surpassing the conventional role in aesthetics. By considering the scope of architectural colour, it may be possible to have a favourable impact at each of the scales of perception. For achieving this, it is necessary to acknowledge the priorities in the specific situations and to dominate the technique of colour precision.

As the city grows and buildings increase in number and size, colour attains power as an artifice capable of modifying perception within different sets of rules, making spaces and places more livable. The development of a colour design method that considers each scale of perception will contribute to satisfy a wider set of demands, from the material scale, for appropriate and high quality finishes, to the visual re-organization of the city.

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colour & human comfort

A Study on Physical Characteristics of White Shoji Paper Used in Traditional Japanese Architecture

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ABSTRACT
In modernism "white" was a colour symbolizing universality and neutrality across the region. White building is still produced at present, and "white" has a special meaning in architecture. However, white is unstable colour because white perception is influenced not only by the physical properties of materials but also by the relative relationship of luminance distribution and surrounding colours in a field of view. In traditional Japanese architecture, shoji paper has been used as a translucent screen at windows and partitions, and it is recognized as one of the typical Japanese white in traditional architecture. The succession and extinction of traditional white and its influence on the modern architecture is focused. In this paper, we measured 23 types of shoji papers for the purpose of understanding the physical characteristics of shoji paper. The results show that it is possible to classify shoji paper roughly from colour and sheet formation index.

Keywords: *white, shoji paper, Japanese architecture*

INTRODUCTION

In modern architecture "white" has been used as a colour symbolizing universality and neutrality beyond regionalism. Even now white architecture is being built repeatedly, and white has a special meaning in architecture. However, white in actual architecture is not always a stable colour, because white perception is influenced not only by the physical properties of materials but also by the relative relation of luminance distribution and surrounding colours in a field of view. Our research investigates the transition of actual "white appearance" in modern and traditional architecture in Japan by collecting design data and measuring spectral reflectance and luminance and chromaticity distribution at actual buildings. In traditional Japanese architecture, shoji paper has been used as a translucent screen at windows and partitions, and it is recognized as one of the typical Japanese white in traditional housing and tea-ceremony rooms. There remains various hand-made shoji paper all over Japan, however, machine-made shoji paper is increasing its popularity recently. We are now focusing on the succession and extinction of traditional white and its influence on the modern architecture. This paper aims to investigate the physical characteristics of various shoji paper as the first step of this research.

SURVEY METHOD

22 types of hand-made shoji paper from all over Japan and 1 type of machine-made shoji paper were collected, and their physical properties such as a sheet formation index which shows the uniformity of the fibre distribution in paper, whiteness, haze value and transmittance were measured.

Total light transmittance and haze value were measured in accordance with the regulations of JIS K 7136 (ISO 14782). Haze meter “NDH 7000” was used as the measuring equipment.

Whiteness was measured in accordance with the regulations of JIS 8715:1999 (ISO 105-J-2). Spectrophotometer “CM-700d” was used as a measuring equipment. It is possible to apply this measurement only on samples within the following range.

$$\begin{gathered} \mathbf{40 < \boldsymbol{W} < 5\boldsymbol{Y} - 280} \\ \mathbf{-3.0 < \boldsymbol{Tw} < 3.0} \end{gathered} \quad \text{----Equation (1)}$$

W: the whiteness index of the sample in the XYZ colour system

T_w: the colour tone index of the sample in the XYZ colour system

The sheet formation index shows the uniformity of the fiber distribution of the paper. It is the uniformity that is visually perceived when it transmits white light. In this research, luminance distribution (I_0) of a surface light source and that (I_n) of a shoji paper placed on it are measured using a CCD camera. The sheet formation index is estimated by the standard deviation of the optical density log10 (I_0/ I_n).

RESULTS

"Momme" is a unit of weight and is used to express the thickness of Japanese paper. 1 momme equals to 3.75 g, normally with paper size of about 60 × 90 cm, however the standard paper size differs depending on the region. Therefore, it is a rough expression of thickness. 3 to 6 Momme Japanese papers were considered as shoji paper in this research. The relation between total light transmittance and haze value is shown in Figure 1. Haze values are calculated by dividing diffusive transmittance by total transmittance, and shoji paper has almost no specular transmittance component, therefore haze value is roughly determined by total transmittance. There are various thicknesses of shoji paper, and the difference of haze is thought to be greatly influenced by thickness.

In formula (1) for calculating whiteness, there were only 7 types of shoji paper that were within the range among the 23 types of shoji paper. The shoji paper was generally perceived as white, but the results showed that its physical value is not always typical white. L*a*b* chromaticity of various shoji paper is shown in Figure 2. It turns out that they are distributed almost along the b* axis. Hon-Minogami, which is said to be the finest shoji paper in Japan, was located in the middle level of all samples. The machine-made shoji paper was found to be close to typical white.

Figure 3 shows the sheet formation index of each shoji paper arranged in ascending order. Hon-Minogami was located in the middle level of all samples. The machine-made paper has the smallest sheet formation index value and this indicates that it is the most uniform paper.

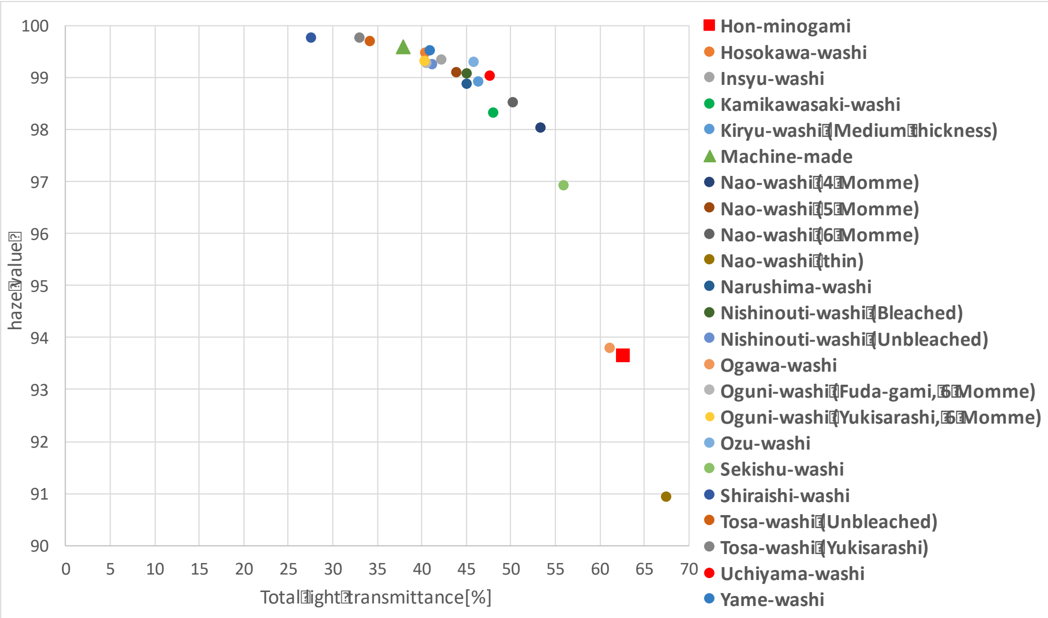

Figure 1: The relation between total light transmittance and haze value.

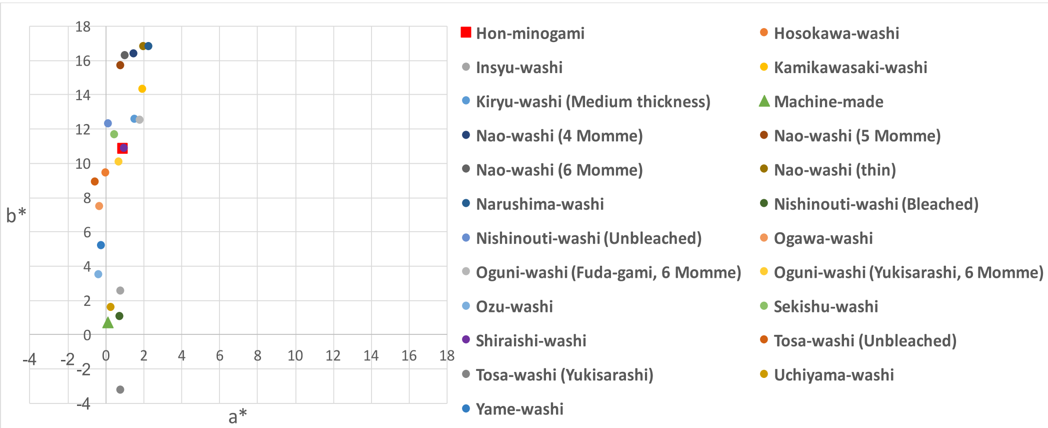

Figure 2: L*a*b* chromaticity diagram of shoji paper.

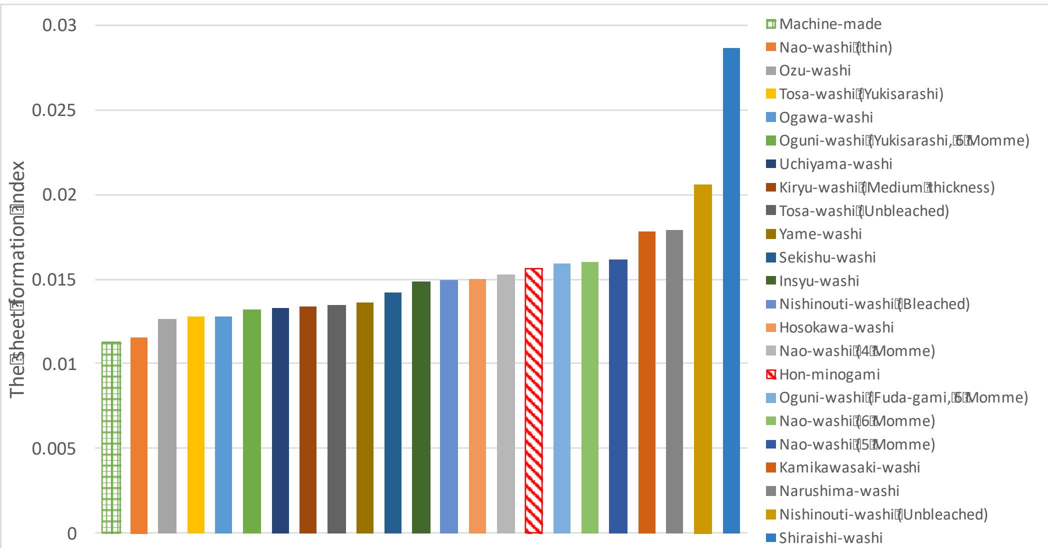

Figure 3: Sheet formation index of each shoji paper measured.

CONCLUSION

The colours of the shoji paper used as samples in the study were distributed along the yellow-blue axis in L*a*b* system and there were differences in sheet formation index of samples, therefore it can be said that shoji paper could be roughly classified using b* and sheet formation index. Despite that shoji paper is not necessarily white in its physical values, Japanese people generally feel that the shoji paper is white. This may be due to an influence of the traditional Japanese wooden brownish houses and the indoor is often kept darker than outside. This paper examined shoji papers only from the physical point of view, however, considering that the perception on colours changes depending on the surrounding environment, further research on colour recognition of shoji paper in the actual spaces will be required in future work.

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JIS 8715:1999 Colour specification−Whiteness of near white opaque materials.

Architectural Colour Design in Defense of Identity and Place; the Challenges and Potential Strategies for the Future in Urban Development

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ABSTRACT

Resisting the erosion of the identity and aesthetics of place requires education, communication, and competent intervention to counteract the deterioration of architects colour knowledge and the developer's indifference. Through the mediation of a discourse on colour that takes its strategy from Kenneth Frampton`s critical regionalism the authors have successfully raised awareness of the problems of colour and the absence of knowledge in chromatic design for context in city developments. We identify this as due to the general decline of colour use and utilisation of colour products that lack relational and regional sensitivity and erode the sense of place, which is a key to long term aesthetic sustainability. Through involvement in the discourse between architect, developer, local authorities and end user we examine where the weakness of process and knowledge arise in who has the power to define and argue for qualities in relation to the economies of production.

Keywords: *architecture, place, identity, colour, design*

INTRODUCTION

The first three images in this paper are recent buildings in Trondheim. They are not unique in the city or in Norway, they are symptomatic of a type of architecture void of contextual and substance qualities, emptied out of architectural and material detail skills. Indeed, much of what is built is in, or near to, this condition of Neo-liberal indifference to regional tradition, context and neighbouring building typologies. Neo-liberalism´s de-regulation of architecture, the erosion of

Figure 1. Three new buildings in Trondheim 2016-18. Images by the authors.

public and democratic interests and the near complete delivery of planning and control into the hands of capital interests be it corporate, the developer or the construction industry is a fact, this development is well documented by many critics, theorists and practitioners. However, even a cursory browsing of the global providers of prefabricated surface and facade materials show a wide range of colour and material qualities some of which have a high level of articulation and subtlety. This begs the question as to why so many buildings are produced with bland surface qualities or inappropriate elements of de-contextualized decor. We can consider the following; firstly, from Guy Debord (Society of the Spectacle 1967) "Following its logical development toward total domination, capitalism now can and must refashion the totality of space into *its own particular decor*… The aesthetic poverty and vast proliferation of this new experience in habitation stem from its mass character, which character in turn stems both from its function and from the modern conditions of construction. The obvious core of these conditions is the authoritarian decision-making, which abstractly converts the environment into an environment of abstraction. The same architecture appears everywhere as soon as industrialisation has begun" In essence the delocalisation of architecture and its aesthetic culture is "globalisation" the "commodification and homogenisation of culture across the contemporary world" (Robertson, 1992, p. 173). We will add to this Frampton's comment "…We are confronted with the paradoxical situation in which, while modernisation continues with unabated voracity at every conceivable technical and structural level, the romance of discovery and invention has lost its popular appeal… (This) reduces the scope of architecture. It renders it incapable of contributing in a significant way to the public values of the society. Among the disturbing structural changes taking place is the ever-expanding power of the multinational corporations; what they value most is a universal, undifferentiated abacus upon which the ebb and flow of value-free exchange and profit can be facilitated and maintained…With such changes, as Marx was to put it, "all that is solid melts into air." (Frampton 1987). Never before has so much been possible on the technical front and yet never before has so much been produced lacking in aesthetic quality, craft and appropriate consideration of place or reduced to a bland normative neutrality. As said, all the potentials in material and chromatics are available but something is missing from the equation. Partly, this is a product of the developer's capital essentialism, which considers aesthetic and spatial quality as an aspect in excess of, or drawing costs from its profit margin. Partly, a result of the subcontracting of material procurement that an distort the architects specifications and finally the inversion of *developing sustainability* to mean the *sustainability of development* in short term profit at the expense of aesthetic sustainability and the long-term social economic benefits of the production of space that is appropriate to psychological comfort. It is here colour and its material manifestation play an important somatic role. The authors find that a key problem also lies in the decline of knowledge and skills at essential stages in the design process "…The general public's discomfort with environmental colourations obviously corresponds to a decrease in knowledge about colours during the last decades. Colours are no longer inseparably connected with specific building materials, processes or styles…on the whole the appearance of our urban spaces is determined not by devoted architects and skillful planners, but by ignorant decision makers and entrepreneurs" Janssen (2001). It is clear that the subtle knowledge of colour in the architectural and planning educations has been eroded to the point of extinction, at least outside the preservation and heritage fields. If we are to address this, we must develop a strategy that uses education and dissemination that provides architects and civil authorities with the tools to bridge the argumentation gap between themselves and the developers. As Pietro Zennaro states "I think that promoting colour culture towards architects is a mission for those who deal in terms of training, skills and knowledge".

PROCESS

In "Ten Points on an Architecture of Regionalism" Kenneth Frampton sets out both and argument for resistance to the homogenising tendency of globalised architecture and manufacturing. The key point of critical regionalism and vernacular form embeds resistance in understanding and working from the acknowledgment that "architecture is culture politics" Account must be taken of geography, topography, light, atmosphere, local materiality and form traditions if new architectural production is to resist the generation of a no-place, globally ubiquitous and neutral. This does not mean resorting to historical pastiche or the quotation of post modernism but rather giving new architecture a meaningful anchorage in the climate, colour, material and spatial traditions in which it arises. For us, it has become a matter of urgency that the discourse in relation to our geographic location is understood and implemented, not as a reactionary aesthetic, but as a useful and necessary embedding of long-term aesthetic qualities. As part of the Light and Colour Centre at NTNU and facing both resistance and indifference publicly and institutionally, we evolved a strategic process over the last five years aimed at tackling the problems of visibility, discussion, education an implementation. Our first strategy was to start a wide-ranging discourse as we saw "mediation" as the necessary for making the issue visible and establishing an understanding of the problem within the public, the profession and local authorities. Frampton's perspective of critical regionalism gave us the understanding that change would need to be «grown» and mediated from our specific needs in a regional base and context. To this end, we started with social media as providing a low threshold information, interest and debate channel. To gather and post commentary we established a public Facebook group "Colour in Architecture". In parallel, we organised an exhibition and conference *Colour in the City*, with local, national and international participants in 2014. This kick started the local discussions with newspaper reports, interviews and invitations to talk to diverse groups on the subject of urban colour. The Norwegian media operates on a large level of syndication of articles from the larger newspapers to small regional papers and diverse web-based media has given a wide national impact (10+ primary national and local reports and interviews with extensive syndication). A colour-mapping project in conjunction with the city heritage office received funding for expansion and this evolved into the request for the production of an extensive colour implementation guide for Trondheim that is nearing completion in 2018. The media coverage of this has resulted in requests from other towns in Norway, to gain insight into this process. This visibility has also generated a large number of requests for advice, assistance, lectures and workshops for architectural practices, housing associations, and local authorities. With specific reference to the architectural profession we have been called on to provide both general insight in architectural and urban colour and workshops related to anchoring new developments in context and providing the argumentation tools towards

the developer. Furthermore, we have recently been asked to develop a NCS course specifically designed for architects by Norwegian Colour Center AS.
Three short case examples:

1. Supporting the architect in dialogue with the developer. We were approached by an architectural practice responsible for a new building at a key junction in the city. The architects were in a state of desperation over the developer's instance on using a glossy bright yellow or grey prefabricated cladding. The architects were fully aware that this materiality was inappropriate to the site but felt they lacked sufficient specific knowledge to make a convincing and empirically founded counter argument. We provided a contextual site analysis, which emphasised the relationship to the ensemble rather than a focus on the object, arguing for what the general site needed as a coherent colour gestalt. We pointed out the how the interactive colour relations would affect the neighbouring buildings and proposed a rendered surface as a more visually ergonomic solution on the sight to reduce glare to oncoming traffic. We also assisted the architects in the presentation to the developer. As a result, the developer agreed to the more expensive rendered facade and has subsequently been complimented by the planning and cultural heritage office on the appropriateness of the solution to the site.

2. Supporting a resident's association in dialogue with architect. We were asked by the resident's association of a converted factory building to comment on an architect's proposals for the facade renovation. The existing facade was in a typical light ochre yellow that was historically prevalent in this type of industrial building. The architect's proposals spanned from the all-white pseudo-functionalist defined as" back to the original", to white with dark and light grey elements defined as "stylish and up to date". While the residents wanted change, they had a suspicion that these proposals were not appropriate but were unable to fully articulate their reservations. We were able to demonstrate that both white and grey were inappropriate in a predominantly north facing facade and that colour choice should focus both on identity of the object and equally on contributing to overall gestalt of a relationship to surrounding buildings, in particular the nearby grain silos.

3. From specialist interest to political awareness. The production of a colour guide for Trondheim first started with a small colour registration and has thereafter been growing in scope. The progress of this has been followed with considerable interest in the local and national media, and we have presented the evolution to the public in various open fora. The guide is intended as relevant to heritage aspects, general use and the possibilities of implementation in new buildings. The public interest generated has resulted in a political party in the local government proposing the allocation 1 million NOK (EUR 105.000) to the project; 25% to dissemination and 75% in grant support towards property owners in the central city zone who are interested in returning buildings to the Trondheim colour pallet.

DISCUSSION

There is clearly substantial dissatisfaction with the bland ubiquity of much current development. It receives intermittent critique but there has been little coherent opposition, partly because much of the architectural profession which could lead such opposition, is at best, passive, silent or subservient, at worst, committed to the perpetuation of illusions of neutrality and so called "timelessness" or "right for our time". It must be said, that a substantial component of the problem lies in the decline in the architectural education of colour material gestalt understanding and consideration of colour in the analysis of a site. In our meeting with professional practice, we have encountered substantial enthusiasm for better colour implementation knowledge, and more than once the question «why didn't we learn about this our studies? ». It is clear that resistance founded in understanding of the regional and local can, through persistent mediation, engage and drive a change in attitude. We have experienced this in our own faculty of architecture. Six years ago, our arguments and interests were treated with, at best indulgence, at worst ridicule; colour was merely a secondary phenomenon, not «real» and so irrelevant to the core of architectural practice. The increased local and national visibility of the question of colour in the urban environment has given us increasing traction to the point where we are currently invited to participate in a range of courses with colour competence. While mediation and public acceptance of the issue go some way towards changing attitudes, a core long-term problem lies in educating architects that understand and can argue for colour. In an increasingly "virtualised" design environment of click, drag and drop from material libraries connected to dynamically updated cost sheets the real becomes ephemeral and in its realisation increasingly divorced from concrete reality of its final actual form and context.

CONCLUSION

Colour and its materialisation pose a challenge, particularly as it is a phenomenon that is so readily subjectified by opinion, critiques of taste and fashion as well as unsubstantiated claims with regards psychological impact. This is often the default reaction across a wide spectrum in the arguments for and against its use. Against this, only a coherent empirical understanding of colour and material interactions and aesthetic contribution that is based in both quantitative and qualitative analysis of real situations within can provide the necessary tools for maintaining the value of the existing, embedding the new.

Within the existing and producing new places that maintain a rational relationship with their bounding environment. This is not a denial of eventual contrast, but rather that proper contrast is only of enduring aesthetic value when it is understood what new architectural production stands in contrast to and in dialogue with. Here both the cultural, historical and contextual understanding that Frampton proposes are a valuable means of embedding the new within the existing and for generating identity connectivity to place. Mediation is essential to raise awareness over a broad spectrum of stakeholders and regional identification with the issue in engaging action for change. As to education, we are fortunate to be in the position to work on this question actively within our institution and with practicing architects, this process will be the subject of a future paper.

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AIC LISBOA 2018
colour & human comfort

Sensory Experience Contours of the Natural and Built Environment: Lisboa - Sydney

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ABSTRACT

> *"Without consciously looking at them, we breathe in our surroundings with all our senses."* (C. Day 1990)

The senses inform the experience of life. Within the context of the experience of life the layering of sensory stimulation is complex. This is further impacted upon by a rapid succession of decisions that engage physical, psychological and emotional responses to surrounding spatial elements. One of the most important of these is the interaction with other people.

The concept of subconscious sensory contours may be viewed as a metaphor for providing information in relation to harmonious and discordant environmental conditions and elements, colour being one of these. An analysis of relationships between conscious and subconscious, of visible and invisible sensory contours may reveal a new way of considering the implementation of colour harmony, in order to support human sensory comfort in the context of interior and exterior architectural space.

Keywords: *senses, architecture, environment, culture, Lisboa-Sydney*

WALK, SEE, SENSE

Placing humans at the centre of architectural design compels us toward the articulation of a deep conception of the human senses. With this focus we are able to observe the many layers of interaction that are affected by human instinct in order to engage with environmental factors. Forged in the present moment during the process of engagement between the human 'senses' with the natural and built environment, a sense of self is shaped through relationships with elements that include other humans and spatial variables. 'Present' moments of experience may be viewed as extensions of human interactions with environmental elements that evolve over time to manifest as culture. Where culture may be viewed as a collective sensory memory of place. 'A place' where physical, mental and spiritual well-being support human existence in an ideal world.

The conception of sensory experience contours provides a context for the expression of a collective sensory memory of place. In order to define this further, it is useful to consider the symbiotic relationship of indigenous people such as the Australian Aborigines with 'the land' or the environment.

Long before the commercialization of Australian indigenous art, diverse aboriginal groups communicated their respective relationships with 'the land' via drawings or marks made in soft iron-rich sands of the vast lands of internal Australia, or in the coastal sands of the vast continent, ranging from near white to deep yellow ochre, depending on location. Some aboriginal tribes are identified by unique mark-making techniques developed to convey stories including those of 'Dreamtime' myths, with natural ochres, ranging from violet, red and yellow and carbon, painted on specially treated bark skin of suitable tree species.

The artworks of Australian aboriginal groups may be viewed as representing individual and collective 'sensory experience contours'. And may be viewed as embodiments of narratives that detail the relationship of time-space-land with human existence. Via generational story-telling, icons and symbols that may be conveyed in a variety of compositions communicate and embody the relationship between human beings and the environment. A story of environmental episodes through time that support the physical, social, cultural and spiritual existence of indigenous Australians.

Australian aboriginal artwork represents collective observations about 'the land', which over time have come to embody the spirit of place and peoples. A relationship with spirit, place and life that is expressed via 'sensory colour contours'. What lessons of observation may be gleaned by designers of spatial environments, to inform a more sensitive approach to the implementation and integration of colour plans?

THE LONG WALK: A UNIQUE HUMAN EMBODIMENT WITH SPACE AND TIME

Walking is a human record in itself and therefore, may be viewed as a cultural construction that organizes all sensory devices of human perception and knowledge.

For Australian Aboriginal groups the expression 'go walk-about' is integral to various layers of living life. From basic hunting and gathering to the experience of milestone rituals of life. To walk means to live life, based on a strong and intimate relationship with 'Dreamtime', family, community and the 'the land'.

Australian Aboriginal peoples develop 'observational acuity' as a result of negotiating the physical environment of 'the land'. With this, accumulative knowledge of favourable and unfavorable environmental conditions, decisions are informed in relation to the support of human needs and environmental comfort. Over time and based on experience, this environmental awareness becomes ingrained not only in the mind, but also in the way that the body physically negotiates environmental conditions through, *'observing, monitoring, remembering, listening, touching, crouching and climbing'* Ingold, T. and J. L. Vergunst. 2008.

Perhaps 'observational acuity' of 21st Century digitally dependent, urban dwellers is limited and may become a hindrance to effective social relationships and interactions, as there is too much emphasis on the visual superficiality of environmental experience due to the need for instant visual stimulation. This mental need for 'over-stimulation', may arise from a lack of conscious connection with the natural environment and cultural layers embedded in the history of a place, and from the need for expedient accomplishment of tasks. The result of this often is the short-lived joy of the experience of super-imposed images on the built environment to further distort and unsettle comfortable synergy between human and spatial environment.

In contrast, embedded in the culture of the Australian Aboriginal peoples, is a respect for ancestral experience of 'the land'. To walk is to 'listen deeply' to the land, the sky, the water, the air, in order to follow existing contours and to also establish new contours, that will sustain life and that will provide 'sensorial prosperity' and human comfort for future generations.

'SPECTRUM OF THE SENSES'

The 'Spectrum of the Senses' model, developed by Meerwein, Rodeck, Mahnke, 2007 may be viewed as a useful tool to aid designers, artists and policy makers to identify the sensorial balance or harmony of spatial environments. Methodology may be based on comparative exploration and interpretive analysis as a means to articulate the physical, mental and spiritual senses that are, or that are not activated in the experience of spatial environments. Possible mapping methods may include film and sound recording; temporal recording of a scene either during different times of day or different times of year; engaging with members of the community in order for them to express individual experiences and may include for example, the experience of the urban dweller verses experience of the tourist, while walking the same route from location a) to location b).

From this point of departure, the synthesis of human sensory environmental experience may be expressed as colour compositions that interpret the juxtaposition of contours of elements within the natural and built environment. Where 'contours' of colour express the relationships of materiality and spatial organization with the intangible senses that impact human experience and memory of place. The outcome of this conception for the synthesis of human sensory experience of environment enables a more wholistic approach that reaches beyond the boundaries of aesthetic considerations.

A question which follows asks, what is missing from current discourse that concerns the design of spatial environments, in both public and private contexts? One of the answers to this question may be deeply rooted in a collective, cultural context, as observes Olafur Eliasson, 2006. Where Western cultures tend to focus attention on objects within a 'scene', the Japanese tend to perceive an overall environment. Interestingly, there is a similar approach to the perception of environment that is adopted by Australian Aboriginals, as discussed above.

The concept of colour-mapping based on the survey of regional colour palettes, forged by the work of Lenclos and others, is based on a framework that focuses on visual aesthetics. But, is it enough to simply survey the colours of buildings, streetscape and environment? While the synthesis of detailed colour identification is useful in determining the history of colour and materiality of a town precinct or urban cityscape, the application of synthesized colour palette recommendations at times, seem to be too prescriptive.

In order to break away from the potential rigidity of colour survey methodology, it is suggested that colour palettes for spatial environments be derived from a framework that informs the exploration and observation of human sensory responses to spatial environments. Where the aim of investigations maps the analysis and synthesis of the interaction between human and environment.

'The Spectrum of the senses' model (Meerwein, Rodeck, Mahnke. 2007, p12) describes human existence, experience and relationships with the environment as based on twelve senses. The analysis of physically, mentally and spiritually oriented senses offers designers of spatial environments, a framework for in-depth and sensitively considered analysis of sensory factors that impact on human comfort and wellbeing in relation to experience and existence.

SENSORY MOMENTS IN SPACE-TIME: LISBOA-SYDNEY

To apply a multi-sensory approach to the experience of environment enables the analysis of layers of a scene at different points in time. And, leads us to consider the character of a city or precinct as a changing scene rather than as a static scene. (Santos, M. Datutop 29, 2007)

In the analysis of a site or scene, often the tendency is to interpret mostly positive elements and experiences, but in order to understand the positive, it may be viewed that the experience of negative qualities such as sharp, short sound, or bright light, or an unexpected passing of an unattractive garbage truck may also be required in order to acknowledge tension in the experience of a scene. By acknowledging discordant sensory elements, we may actually broaden the scope of understanding of the potential impression of a spatial environment and in turn, to also broaden the design possibilities in the context of colour palette design.

Lisbon located in the northern hemisphere and Sydney located in the southern hemisphere of planet earth, are harbour cities that have evolved as a consequence of interactions with the element of water. This common characteristic may be interpreted as a subconscious sensory contour that has been 'internalised' by a collective conscious over time. The ebb and flow of water that frames the experience of cityscape, expresses the culture, identity and spirit of place. This is exemplified in the brief comparison of the sensory experience of the world renowned, Sydney Opera House and the new addition to the cultural fabric of Lisbon, The Museum of Art, Architecture and Technology (MAAT).

The evolution of the development of the environmental sensory contour of water common to both Lisbon and Sydney has origins in human activity based on the action of walking. Where walking along a specific route, either alone or in a group, enables the fulfilment of certain activities to support human comfort and survival. The walk to approach the foreshore in turn, activates one's relationship with water. The flow of the major waterways of the respective cities of Lisbon and Sydney enable active connection in different ways. The flow of the Atlantic Ocean to the Tagus River of Lisbon is linear and direct and contrasts with the undulating flow of the Tasman Sea to Sydney Harbour.

The 'spirit of place' is primarily experienced by 'breathing in the atmosphere' of space, place and structure that is expressed through the composition of materials used, as experienced through the direct field of vision which interestingly is mostly ground oriented. Where the composition of repeated modules has the effect of engaging with a person's experience through visual rhythm, through harmony of gradated continuity that synchronises with the kinetic movement and scale of the human body, thus leading to human comfort through spatial experience. However, it is interesting to observe that the modular composition of gradated tile modules in both the Sydney Opera House and MAAT Lisbon, enable visual experience to be stimulated skyward. Thus, enriching the overall sensory experience of space via the contour juxtapositions of built and natural elements with the sky and ambient conditions of weather.

SKY-WATER: LISBOA-SYDNEY

The experience of the rhythm of the city of Lisbon and of Sydney is impacted on by the opportunities to experience vistas. To extend the gaze beyond, to engage visually with activity further afield on the water or in the sky or across bridges. Immersed in the thick of high-rise buildings of Sydney, time seems to slow and to almost stand still. In contrast, the flow of naval traffic or the flurry of seagulls in flight, give a sense of the flow of time relative to the parameters of space.

It is the mentally oriented senses of ambient temperature, sight, taste, smell which impact immediately in relation to how the 'spirit of place' is communicated and experienced. However, referring to the 'spectrum of the senses' model, it becomes apparent that the 'scope of action' oriented senses of touch, comfort, movement and balance all contribute to the formation of the 'soul' of 'place' over time. This suggests scope for the exploration of the spiritually oriented senses (Meerwein, Rodeck, Mahnke, 2007) in order to articulate the significance of place through sensory experience contours of colour juxtapositions that express this concept.

If talking and walking and thinking go hand in hand, the physical body reacts through rhythm of pace – fast or slow – which in turn affects the pulse rate and rate of breathing. Where slow, steady pace and breath allow for connection with the meaning of a place and for the formation of one's own personal meaning of place. Quickened pace and breath may either lead to elation or tension in relation to the experience of spatial environment. Standing on the podium of MAAT looking out at the Tagus River or back toward Lisbon city stimulates connection with the spirit of place – even as a visitor.

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How colour effects comfort in urban space

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ABSTRACT

How colour effects comfort in urban space was explored in two collaborative projects by Colour Your City. Both invited an open dialogue with the public using a #ColourChat format in which a series of questions were posed at interactive installations.

In Durban (February 2018), these were combined with a photography exhibition which colour mapped the city, and PatternNation's playful blob sculptures. In Berlin (April 2018), as part of the Museum of Colours' *Colours in (Dis)Order* there were two installations including a public space activation at a former watchtower of the Berlin Wall in a nearby park.

It was found that colour in urban space is closely associated with comfort and positive emotions, such as boosting mood, creating a sense of aliveness, inspiration and expressiveness. Conversely grey was seen as depressing. Areas for further research include the impact of specific hues, categories of colourful interventions, and site-specific studies.

Keywords: *colour, urban space, environmental colour, human comfort, placemaking*

INTRODUCTION

Defining comfort: Comfort is understood as a state of physical ease, contentment, and a satisfying or enjoyable experience. The word's etymology has Latin roots meaning 'strengthen' (Oxford Dictionaries). The focus of this research is human comfort in urban environments, and specifically the impact of colour on comfort.

Urban dominance: By 2050, 66% of the world's population will be living in urban areas (United Nations, 2015). Human comfort and quality of life matter, and it is therefore important that there is greater awareness about what constitutes good design in the built environment, of which colour is paramount. As the American architecture critic Williams Goldhagen (2017) states:

> "The more we learn about how people actually experience the environments in which they live their lives, the more obvious it becomes that a well-designed built environment falls ... somewhere between a crucial need and a basic human right."

Placemaking: To better understand what makes urban space comfortable, we consider placemaking, which aims to make public spaces into vital places that serve common needs, so they become well used and loved by citizens. The Project for Public Space (PPS) identifies key attributes of great places as: Comfort & Image. With the following factors being important, whether a place is: safe, clean, green, walkable, sittable, spiritual, charming, attractive and historic. They identify that great places promote a sense of comfort and are visually pleasing, generally stimulating, foster a sense of belonging, greater security, better environmental quality and a feeling of freedom.

Environmental colour: According to Mahnke (2012), human-environment-reaction in the architectural environment is largely based on the sensory perception of colour, it exerts a huge psychological and physiological influence. In order to understand further colour in the urban setting, we consider that environmental colour can be defined as the total colour of a particular space which includes natural elements, spatial patterns, colours of the built form, urban elements and also patterns of human activities (Ronchi, 2002).

Approach: Colour Your City is an organisation dedicated to transforming and enriching urban space with colour. Colour Your City's perspective is to regard urban space as a canvas for creativity, and reimagine it with colour to energise the space and serve wellbeing. Colour Your City wants to see cities where city makers use colour consciously and where citizens are better connected to space, creativity and community. Colour Your City produces site-specific transformations, researches the impact of colour in urban space, has an artist stable of colour-centric artists, and helps organisations to use colour more intelligently. Colour Your City believes in dynamic, energising, playful, fun and intriguing urban space.

Communicating with citizens about the role of colour in urban space is at the heart of Colour Your City. Two collaborative projects have been used as case studies to explore colour and comfort in cities. Both projects invited an open exchange through a #ColourChat question series posed to the public at interactive art installations. This enabled an open exploration into public perception and feelings towards urban colour.

EXPERIMENTAL

1) Colour Your City x PatternNation – Durban, South Africa

Colour Your City partnered with Cydney Eva of PatternNation to colour map the coastal city of Durban in South Africa, and produce two interactive art installations in February 2018. PatternNation is a collaborative visual art and design label aimed at connecting artists who embrace bold colour and pattern globally. The installation comprised of:

1. Photographic exhibition of images taken on several walks to colour map (i.e. visually document) the existing colour palette of the city. Getting 'out on the streets' is vital to understanding city space, as de Certeau (1984) states: "The act of walking… is to the urban system what the speech act is to language".
2. Play sculptures – affectionately known as 'blobs' – made of upcycled textiles filled with balloons to form cloud-like shapes that were hung from trees.

3. #ColourChat conversation series hung amidst the blobs. Each had a key question that explored colour in the city, with a pen for people to write their responses. The questions were posed in an open manner, without specifying a site/location or type of colour, in order to keep the conversation accessible and expansive.

The installation took place at two sites:
1) **First Thursdays Durban** on Station Drive outside Open Plan Studio: An art-focused monthly evening event with approx. 500 visitors predominantly aged 20-30 years.
2) **I Heart Market**: A monthly makers market held during the day, located next to the Moses Mabhida Stadium with approx. 750 visitors and many families.

Figure 1: installation at First Thursdays on Station Drive.

Figure 2: #ColourChat respondent at I Heart Market.

Figure 3: Playing with the blob sculptures at First Thursdays.

Nine #ColourChat questions in total were posed, out of which the following have been selected as most relevant to exploring comfort:

How does colour impact your comfort?
Most respondents expressed positive sentiments: "Brings joy" "Colour makes me feel alive and more comfortable with myself" "Helps make us feel expressive". Several stated the variable impact that different types of colour have, depending on their own feelings/mood, and on the invigorating/bright or calming/neutral nature of the colour.

Does a lack of colour effect urban space?
A unanimous yes! Several anti-grey references: "if you paint the walls grey the people will follow".

How does colour improve attractiveness in the built environment?
Responses related to:
ALIVENESS: "It creates warmth, brings life and community into otherwise dead space. Personality" "Brings life to the lifeless" "Makes it inviting" "Welcomes"
MOOD IMPROVING: "Makes it look happy" "It raises your mood" "Elevates the mind" "Makes you smile when you're in the city" "Puts a smile on my face"
INSPIRATION: "Positive. Makes being in town inspirational" "Makes you feel inspired"

2) Colour Your City x Museum of Colours – Berlin, Germany

The *Colours in Dis(Order)* exhibition took place at the Museum of Colours in Berlin, Germany during April 2018. Colour Your City participated in the exhibition with two #ColourChat installations: one inside the exhibition space at Am Flutgraben, and a second outside at the nearby Kommandoturm (watchtower) in Schlesischer Park. The watchtower used to be part of the Berlin Wall, as a tool of surveillance and division to control of the flow of people. Today it stands alone in a very multicultural park, with the lower region covered in graffiti and occasional tours inside the tower. The aim of placing a second #ColourChat installation there was to give the tower a temporary new lease of life and positive purpose, activating the space in a new way.

Figure 4: #ColourChat respondent inside exhibition at Am Flutgraben.

Figure 5: Respondents outside at Kommandoturm in Schlesischer Park.

Twelve #ColourChat questions in total were posed, out of which the following have been selected as most relevant to exploring comfort:

How do you feel about grey in the city?
Most responses referred to negative emotional impacts: "depressed" (the single most common answer) "sad" "boring" "uninspired" "lonely" "cry" "dreary" "lifeless" and a sense of "monotony/routine". There were a couple of nonchalant answers and one positive: "it's part of Berlin's charm". There was a popular call to "Let's colour it".
Clouds and rainy weather were also associated with grey.

How can colour be used to improve urban space?
Most responses indicated pleasing emotional and mood-boosting impacts, such as making people smile and be happier: "To lighten it. To improve joy" "To influence people's mood" "Love, peace & harmony" "Expression".
Reference was made to outdoor activity: "Be the bridge between people in urban space - call them for outdoor wandering".

Practical suggestions were also made, such as: "Flowers and plants between the cracks and vacant spaces" "Street art" "Paint the grey!"

RESULTS AND DISCUSSION

People's responses in both Durban and Berlin were overwhelmingly positive in relation to colour in the urban environment, with a lot of pleasurable emotional value (joy, aliveness, expression, inspiration) and clear indicators of comfort (contentment and enjoyment) associated with colourful urban settings. It was also clear that colour has variable effects depending on the nature and hue of colour, and the individual's mood. Conversely grey was seen as depressing and sad. There were many calls for more colour in the city. This helps demonstrate that colour is a vital factor to human comfort in urban space.

In both cities (especially in additional #ColourChat questions – the results of which are beyond the scope of this paper) there were many calls for more colour, through forms such as street art and nature. We see that there are many practical ways in which to increase comfort by having more creative, artistic and/or nature-oriented ways to add more colour to the city.

The open nature of the installations and ease of participating in the #ColourChat was beneficial for maximum accessibility and a free exchange on the topic, however this was challenging to analyse from a data point of view, since detailed demographic and other data sets were not collected.

Areas for further research include looking at refining the #ColourChat format further to gather participant data. Also to consider the effects of specific colour hues, types of colourful interventions in urban space – both general categories and site-specific studies.

CONCLUSION

We can see that colour plays a major role in our experience of life and levels of comfort. This connection between colour and human comfort in the context of urban space is a pressing and important one, and is to be explored further by Colour Your City, to help shift urban habitats from often being poorly designed and inadequately executed, to places that serve human wellbeing and enhance vitality.

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AIC LISBOA 2018
colour & human comfort

Walkability and Colour Experience: Façade Colours and Pedestrian Walking Preferences on Urban Streets

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ABSTRACT

Physical aspects of the urban built environment are known to have significant influence on the pedestrian experience. Walkability researchers have studied this relationship focusing on physical aspects of the urban built environment in various scales. Besides the larger and commonly accepted indicators such as density, diversity, destination accessibility and distance to transit, smaller scale attributes grouped under the design indicator have also been subject of study. This paper seeks to explore the effect of building façade colours on the walkability of urban streets, which have been considered to affect the perceived complexity of the streetscape and thus make it more interesting and attractive to pedestrians. Online surveys were utilized within our study to understand people's attitudes to varying cases of façade colour combinations in the Lapa neighbourhood of Lisbon. The results of the study indicate that the diversity and perceived pleasantness of façade colours on an urban street has a very close association with walking preferences.

Keywords: *walkability, urban design measures, built environment, façade colour, colour experience.*

INTRODUCTION

Walkability is simply defined as a measure of how suitable and preferable an urban area is for people to walk through, and perceptual qualities of the built environment are of concern regarding the walking behaviours of people in that environment. These qualities influence the individual responses of the pedestrians such as the sense of comfort, sense of safety and level of interest, thus affect the level of overall walkability. Understanding the perceptual qualities of an urban environment helps to determine people's perceptions of streetscapes and their attitudes to a streetscape (Nasar, 1994). Several studies have investigated the relationship between the quality of the built environment and walking behaviour of individuals in urban neighbourhoods. Various walkability indices have been developed to quantitatively measure the urban design qualities of streets and inform urban design decisions to improve walking conditions. Besides larger scale indicators such as density, diversity, and accessibility; perceptual qualities regarding the design of an urban environment have been found to influence the overall walkability of urban streets (Ewing and Clemente, 2013). In their study, Ewing et al. (2006) identified the five objectively measurable perceptual qualities of an urban environment as imageability, enclosure, human scale, transparency, and complexity.

Complexity is the main focus of this study. It refers to the visual assessment of an urban environment that shows variations within its features like shape, size, material, colour, and ornamentation of buildings along with other streetscape features like the existence of urban furniture. It is assumed that when an urban environment is more complex, it becomes more attractive, interesting, and therefore more walkable. Ewing and Clemente (2013) considered the number of building façade colours on a street as one of the indicators of complexity. People prefer building façades with a high variation and complexity rather than being in a unity and coherence as Janssens claimed (1984). Janssens (2001) also found in a study that, the colours of the built-environment increase brain activation by contributing to the feelings of pleasantness and spaciousness. O'Connor's (2008) research investigating aesthetic response to building façade colours drew positive correlations in aesthetic responses in both cases where façade colours were harmonious with the surrounding environment as well as contrasting.

THE STUDY

This paper explores the relationship between walking preference and façade colours on urban streets. Our study aims to evaluate people's attitudes and experiences of building façade colours in an urban environment as one of the indicators contributing to walkability.

For our research, a part of Lapa district in Lisbon, Portugal was selected for a case study due to its rich variety in façade colours and glazed tiles. Each building façade's paint or tile colour was in-situ measured, identified by using the NCS (Natural Colour System) colour notation system and classified in order to create a colour map of the study area. The colour of each façade that was overwhelming the majority counted as the basic building colour and utilized for the colour mapping of the selected neighbourhood (Figure 1). In accordance with the colour mapping analysis, specific cases where neighbouring building façades with (1) neutral colours, (2) warm colours, and (3) diverse colours were determined and photographed. Several façade sequences were photographed per case indicated above and three were selected per case, thus, nine photographs were selected to create online surveys (Figure 2).

A total of 36 participants volunteered for the survey. Each participant was subjected to a number of selected photographs to gather answers to the following questions for each photograph.

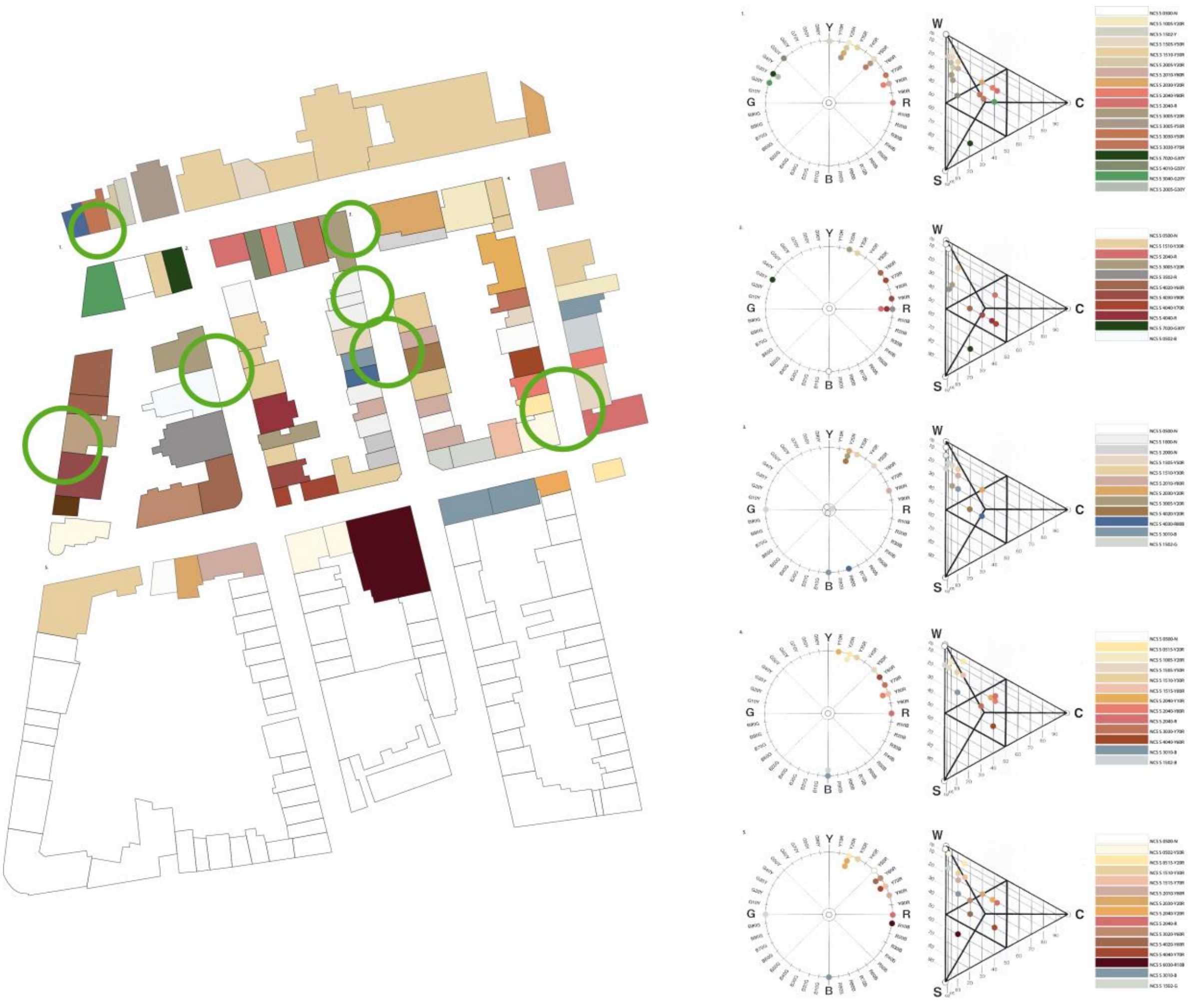

Figure 1: Colour map and NCS analyses of the study area in Lapa district (the green circles on the colour map show the locations where the photographs were taken).

1- How attractive is this street?
2- How likely would you take a picture on this street?
3- How would you like to walk on this street?
4- How do you like the building colours on this street?
5- How pleasant do you find the building colours on this street?

The questions were created with the intention to develop an understanding of how pleasant people find the building façades and how likely they would choose to walk on the street by asking them directly and indirectly about building colours and walking preferences. Each question was answered by a five-point Likert scale, ranging from the lowest level of preference or not agreeing with the statement at all to the highest level of preference or completely agreeing with the statement. The questions from one through three were to measure the walkability-related responses of the participants regarding the presented street; whereas the questions four and five were about the participants' attitudes to the building colours of the same street.

a. Neutral Colours

b. Warm Colours

c. Diverse Colours

Figure 2: Three street photographs for each category, a. neutral colours, b warm colours, and c. diverse colours (photographs were taken by the first author).

RESULTS

The total scores of each question were calculated and the façade colours were categorised under neutral colours, warm colours, and diverse colours. Table 1 shows the total scores regarding each question.

Table 1: Total scores of the colour categories according to the questions

Façade colours	Attractiveness of the street	Take a picture of the street	Like to walk on the street	Like façade colours of the street	Pleasantness of façade colours of the street	Total score
NEUTRAL	131	113	142	133	126	645
WARM	169	158	165	176	162	830
DIVERSE	186	168	200	191	201	946

The results on Table 1 show that the photographs of the façades in the “diverse colours” category received the highest score and total value of positive attitudes, specifically to the questions about “like to walk on the street” and “pleasantness of façade colours of the street”. The lowest number of positive responses were received by the photographs of the façades in the “neutral colours” category. The photographs of the façades in the “warm colours” category received higher number of positive responses than the “neutral colours” but lower number of positive responses compared to the photographs in the “diverse colours” category.

A Pearson's product-moment correlation (Pearson *r*) was run to assess the relationship between walking preference and façade colours on the streets. The analyses showed the relationship to be linear with all variables normally distributed. The value of $r \pm 0.70$ and above was used to interpret the predictability of the relationship between the variables The correlations of the questions indicated in Table 1 regarding the corresponding photographs within each colour category are as follows (see Figure 2);

1- **Neutral Colours:** There was a strong positive correlation between "attractiveness of the street" and "like to walk on the street", *r* = .711, in the first photograph within this category. For the second photograph, there were strong positive correlations between "pleasantness of façade colours of street" and "like to walk on the street", *r* = .896; and "attractiveness of the street" and "like façade colours of the street", *r* = .871. For the third photograph within this category, there was a strong positive correlation between "attractiveness of the street" and "take a picture of the street", *r* = .875.

2- **Warm Colours:** There was no strong correlation between the variables in the first photograph within this category. For the second photograph, there were strong positive correlations between "attractiveness of the street" and "pleasantness of façade colours of street", *r* = .852; "like façade colours of the street" and "take a picture of the street", *r* = .846; "like to walk on the street" and "take a picture of the street", *r* = .837; "like to walk on the street" and "like façade colours of the street", *r* = .778. For the third photograph within this category, there were strong positive correlations between "attractiveness of the street" and "like façade colours of the street", *r* = .900; "like façade colours of the street" and "take a picture of the street", *r* = .812; "pleasantness of façade colours of street" and "like to walk on the street", *r* = .810; and "attractiveness of the street" and "take a picture of the street", *r* = .705.

3- **Diverse Colours:** There was a strong positive correlation between "attractiveness of the street" and "like façade colours of the street", *r* = .702, in the first photograph within this category. For the second photograph, there were strong positive correlations between "attractiveness of the street" and "like façade colours of the street", *r* = .959; "pleasantness of façade colours of street" and "like to walk on the street", *r* = .860; "attractiveness of the street" and "take a picture of the street", *r* = .849; and "like façade colours of the street" and "take a picture of the street", *r* = .803. For the third photograph within this category, there were strong positive correlations between "attractiveness of the street" and "like façade colours of the street", *r* = .849; and "pleasantness of façade colours of street" and "like to walk on the street", *r* = .796.

DISCUSSION AND CONCLUSIONS

Finally, a Pearson's product-moment correlation was run again to evaluate the relationship between the variables. Although primary analyses indicated all the variables had a strong positive correlation value ± 0.80 and above, the value ± 0.90 and above were taken into consideration to interpret the relationship with the variables. Regarding the results, pleasantness of façade colours of a street has a very close association with preference to walk on that street (*r* = .964). In addition to that, attractiveness of a street has close associations with liking façade colours of that street (*r* = .942) and this would also act as a reason to take a picture of that street (*r* = .928). Solely liking façade colours of a street has also a close relationship with taking a picture on that street (*r* = .919).

Even though a preliminary study, our results are in line with the literature stating that the diversity of façade colours contribute to the perceived complexity of the streetscape and thus make it more attractive to the pedestrian. We acknowledge that increasing the number of photographs per case and the number of survey participants, as well as controlling for other variables in the photographs such as the building age and condition would strengthen our research. Also, judging streetscapes based on photographs instead of the actual streetscape at the physical location might have caused some bias. Regarding this problem, the participant responses are considered to be consistent since the results are analysed relatively within the three cases. Nevertheless, this study can act as an initial step in establishing a framework based on which designers and urban authorities can be advised in deciding on colours of individual buildings and managing colour codes in urban neighbourhoods.

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Chromatic planning for Urban Furniture - case studies for a design methodology

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ABSTRACT

This paper aims to present, the case studies intended to test a design methodology to be applied in urban chromatic plannings to urban furniture. This methodology, that takes in account all environmental colours from the chosen urban areas, allows the establishment of their dominant colours and, consequently, makes it possible to define the urban furniture colours, which should make a chromatic and luminosity contrast with the environment. Simultaneously, this contrasting colour application to urban furniture will transform its elements in inclusive factors and will, also, contribute for the local identification and, in big cities, where all the neighbourhoods may have each one colour for its urban furniture, it will ameliorate the city orientation. The present case studies, are six settlements from two Municipalities on the outskirts of Lisbon, and they have different dimensional, anthropological and topographic specifications. The comparison between them allows the methodology validation.

Keywords: *Colour Methodology; Urban Furniture; Urban Chromatic Plans; Inclusivity; Identification.*

INTRODUCTION

The main purpose of this paper is to present, the case studies intended to test a design methodology to be applied whenever there is a need to create urban chromatic plannings to urban furniture. This methodology aims to originate a system that will ameliorate urban furniture use, improving the visibility and legibility of its elements, transforming them in identification factors for the different city neighbourhoods, and contributing to a better orientation within the cities. Contrarily to other methodologies, this one is intended to be applied solely to urban furniture and transform its elements in ergonomics and inclusive factors, not interfering with the city architecture or other elements of city signage, encoded by road legislation.

Cities, and especially the contemporary ones, may be a complex of streets, architecture and open spaces, often lacking differentiation in their architecture and without obvious reference points that could establish a base for wayfinding/wayshowing maps. This complexity causes confusion and orientation difficulties and, also, reduces considerably the direction sense of their visitors and inhabitants. To solve this problem there was a need to create networks of orientation and identification elements that would help city users to find their way, including the signage and the urban furniture elements, which need to be clearly seen in order to fulfil their functions.

These signage and directional systems, tend to be generalized and this standardization leads to a recognition of signage symbols by an increasingly itinerant population that finds the same signs all over the world. Even more, the signage systems responsible for giving guidance to city dwellers are designed for being perceived at a distant and fast vision of people driving motorcars on roads and highways. Within the cities, these systems are not appropriate to be seen by pedestrians or fulfil the needs of the entire population, because they tend to merge with the building colours and loose visibility. So, to solve this problem, it became necessary to design comprehensive directional systems that could help guiding people and, simultaneously, grant a better identification with the city.

URBAN FURNITURE AND COLOUR

The urban furniture elements don't have a mere decorative function, as Quintana (Creus 1996 apud Serra 2000: 6) claims: "These elements are objects which are used and which are integrated in the urban landscape, and they must be comprehensible to citizens. Use, integration and comprehension are thus basic concepts when it comes to assessing any set of objects we might come across in a city's public spaces".

Considering that, in order to accomplish its functions, urban furniture needs to be seen and an appropriate colour application improves considerably its visibility. The application of a chromatic planning to urban furniture may originate a system which will function simultaneously as an identification factor for the different city quarters and as an orientation factor for its inhabitants and visitors. Also, when referring to signage chromatism, Costa (1987:182) says that it must be "an integration factor between signage and environment", although it is usually restricted to the shape and background contrast within the signage elements, following the options described on the roads code or using the black and white achromatic contrast and not considering the contrast with their environment, which is essential to their visibility.

Colour applied to urban furniture or signage systems, is the easiest way to improve the visibility and legibility of these elements, and simultaneously, this application can achieve the identification of the different city zones, and promote the orientation of the population, permanent or temporary. In fact, as a mean to show the way, colour has been punctually employed successful in interior and exterior spaces and, therefore, we could assume that a sensible and general application to urban furniture, may be a way to the successful resolution of the orientation problem within the city. On the contrary, a bad use of colour in urban furniture and signage systems contributes to their lack of visibility, that is an impediment to the fulfilment of their functions as well as it is a factor of social exclusion for people with deficient and older vision. Considering this, Per Mollerup (2005: 161) refers that "colour can be seen from longer distances than other graphic elements" and that "[…] in signage differentiation is the first and foremost role of colour".

Considering the whole population and, within it, the percentage of people with visual impairments, there are some constraints that must be respected. Every present object must detach himself from the background, in order to be recognized as obstruction, and every urban furniture element — fences, bollards, lamp posts, litter bins, benches, etc. — must present a strong colour and tone contrast with the environment, because they are the most effective means of improving visibility, with tone contrast usually the more effective. A conventionally pleasing coordinated colour scheme can usually be significantly enhanced with good tonal contrast (Barker et al 1995: 7-51), in order to stand out and be more easily recognized, among other, by visual disabled people.

METHODOLOGY FOR URBAN FURNITURE CHROMATIC PLANS

The concern to establish a coherent urban image through colour studies and chromatic plans is relatively recent, despite some pioneer cases, and led to the conception of chromatic planning methodologies, gathering the necessary steps for the selection of a colour palette that would constitute the urban image. Urban plans that are concerned with colour application, generally employ methodologies directly related with the cities different characteristics and are mainly focused in architecture. Thus, it has become necessary to develop a new methodology that is now being tested in order to be validated.

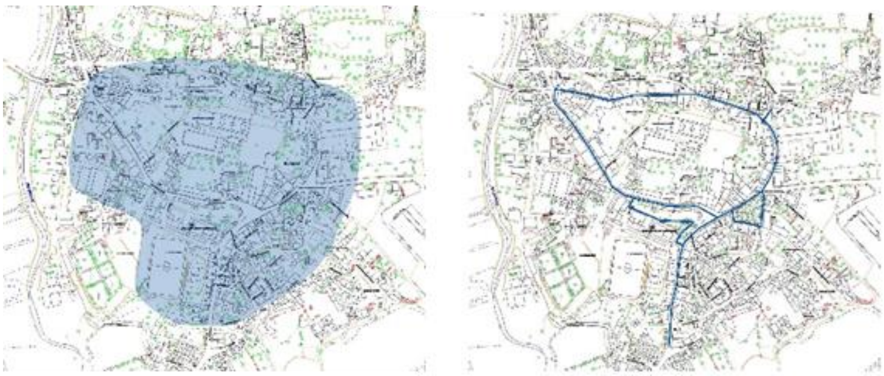

Figure 1: Bucelas' chosen area and sample route. Source(s): paper authors.

This methodology applies to the study cases an extensive direct observation, with the use of mechanical devices, including photographic mapping of both urban furniture and signage, in order to evaluate their visibility and legibility, as well as their colour applications. To facilitate the study, samples areas were defined for each urban area, including the main streets and places and, also, some secondary ones, with the intention of encompassing the most representative zones, those with specific characteristics.

Along the selected areas, an exhaustive record of all the environmental colours is made, including material samples not only from the buildings, but also from pavements, vegetation and any additional elements present with a relative permanence in the urban environment – *the non-permanent colours* – that should be taken into account for the spatial chromatic readings. Afterwards, all these records are classified using the Natural Colour System (NCS), that was chosen because it allows the easy identification of every colour, even when they are located out of reach, and without needing additional equipment. Besides the NCS classification, whenever it is possible, the colorimeter is used for a more accurate measurement of colours.

All the collected data must be complemented with the background dominant colours, and with photographs of the environment elements and panoramic views from the different blocks. The angle of the streets is also evaluated in order to determine the percentage of sky colour present in each street, since this colour interferes on the urban area colour and, therefore, must be included in the colour palette.

It must be underlined that the recorded colours are perceived colours, not always coincident with the inherent colours (the real colours belonging to pigments and materials) and that the perceived colours may, also, be a partitive synthesis, particularly in the case of vegetation and tiles coated walls.

Also, when recording the environmental colours, we must take in account all the perceptive factors related with colour interactions, as well as the geographic and atmospheric conditions and the chromatic variations along the different climatic sea-sons. With this purpose, the palette is tested along the seasons' changes to judge the chromatic alterations aroused from the different colours of the vegetation as well as day light variations and sky colours according to weather changes to evaluate the chromatic plan pertinence.

Figure 2: Percentage of visible sky. Source(s): paper authors.

All these colours are recorded on forms and maps, previously designed and tested, in order to create a data base that will allow the identification of the town dominant colours. In order to guarantee the scientific rigor on each quarter chromatic plan determination, we consider the dominant colours, proportionally represented, choosing colours to the urban furniture which may establish an adequate chromatic and luminosity contrast with the dominant colours and, also, respect the traditions, culture, identity and history of the quarter. These contrasts must be observed under the possible local illumination variations, in order to be sure that they accomplish efficiently their functions (Gamito 2012: 108-113).

These dominant colours, and the contribute of the local history and culture, lead to the establishment of a very comprehensive urban furniture chromatic plan, based on scientific rigor.

The urban furniture chromatic plan, which will be different for every settlement, must stand out from the environment, contributing for a better legibility and identification of these elements and, in the same way, will become a city's area identification element which may be used in different supports and, this way, facilitate the orientation and wayfinding within the city.

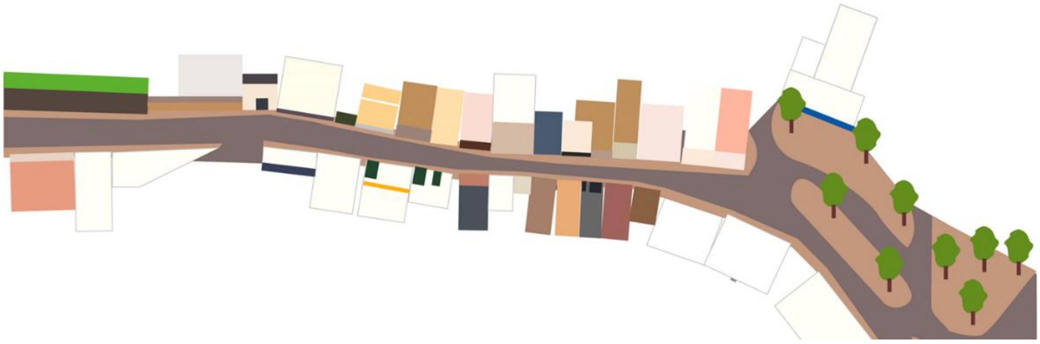

Figure 3: Luís de Camões Street/Bucelas, represented graphically on their chromatic proportions. Source(s): paper authors.

CASE STUDIES CHARACTERIZATION

The referred methodology is being tested in two municipalities located in the outskirts of Lisbon (Portugal): *Loures*, a municipality away from the river Tagus and constituted by traditional, modern and rural settlements, and *Oeiras*, a municipality that have settlements both on the interior and on the sea front, being at the same time a miscellanea of old and modern. In each municipality where chosen three settlements, that became the research case studies, with different dimensional, anthropological and topographic characteristics, but with some similarity between them which allowed making comparisons.

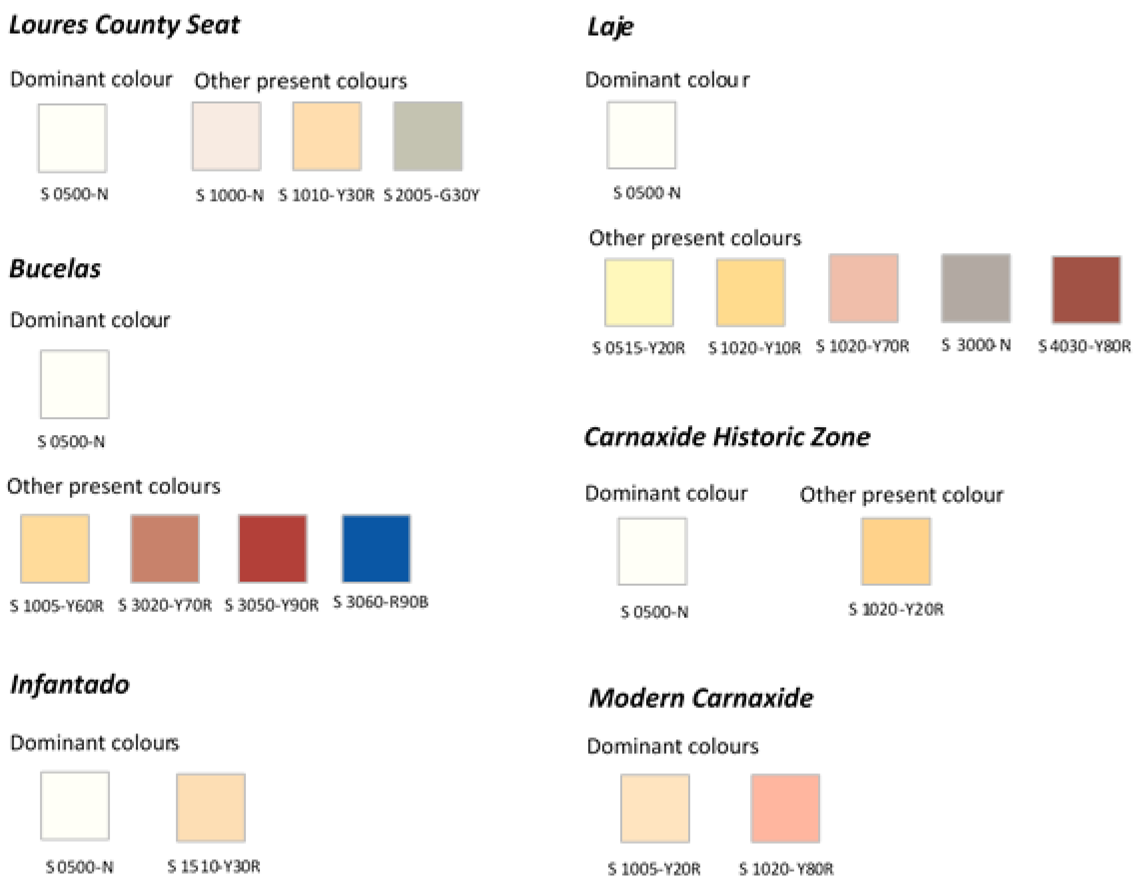

Figure 4: Case studies' dominant colours. Source(s): paper authors.

In each municipality was selected a modern settlement – *Infantado* in Loures and a *modern neighbourhood* in Carnaxide/Oeiras – both newly built and with colours determined by the respective projects. Also, in both was chosen an historic settlement – *Bucelas* in Loures and the *Carnaxide Historic Zone* in Oeiras. The other two settlements do not allow such an easy parity, except for the diversity of their composition. In Loures Municipality was chosen the *County Seat* that has grown over time and has a diversity of construction ranging from the remnants of a village to the multi-storey buildings of recent construction. In the municipality of Oeiras, *Laje* is a differentiated cluster, instituted by the municipality, that includes Social Lodgings, with buildings all alike, belonging to the municipality, and to whom the inhabitants pay rent; buildings belonging to the inhabitants, to whom the municipality sold the land and the projects; and AUGI, a neighbourhood that is inhabited by displaced populations to whom the municipality gave plots not interfering with the construction. Its buildings don't exceed four-stories, and the ground configuration is more or less rough with several hills.

In all these settlements the dominant colours are identified, which, together with the knowledge of local traditions, will allow the choice of colours appropriate for their urban furniture.

CONCLUSION

With this project, which is a work in progress, we aim to test and validate a methodology for urban furniture chromatic planning through the presented study cases. This methodology will define and underline the importance of colour application to urban furniture, taking in consideration that a pertinent chromatic plan can contribute for a better visualization and, consequently, turn urban furniture into an inclusive factor, contributing for a better utilization of its elements and, simultaneously, ameliorating the orientation within a city or an urban region and identifying its different zones.

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Colours technology for an innovative Reclamation Architecture

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ABSTRACT

Within the broad area of landscape design and enhancement there is a growing interest in the valorisation of spaces where the reclamation architectures are built. In a recent research has emerged the need of requalification of reclamation buildings and systems: hydraulic supports, pumping stations, water towers, and so on. In many situations, in Italy, these hydraulic constructions are situated in a natural context, but the design is not integrated with the landscape, it has a very bad impact. Then, what is the correct design approach? Is it more important to design colour integration within the natural context on taking a high colour approach increasing the visibility of the artefact, or a low colour impact is preferable? The colour role in this context will be analysed by looking at the relationship between natural landscape colour and the artefact colour in many projects realized in the contemporary European context.

Keywords: *colour, landscape, reclamation architecture, environmental quality*

INTRODUCTION

In the last century, the landscape reclamation of Po Valley (Italy) has been very important in terms of economic and social development of the country. Especially for the expansion of agriculture on the drained areas of the swamps because there were built many drainage systems to ensure public safety from flooding and for public hygiene. Then, at that time there had a great development of innovative reclamation machines to water technology. The operations were conducted with the contribution of Reclamation Consortia who have restored the flooded fields. The Reclamation Consortia of Veneto Region have built a significant amount heritage of hydraulic construction, spread over large areas and which includes systems of considerable complexity, among which in particular the constructions for the pumping stations. In the last few years it has emerged the need of enhancement and requalification of reclamation systems, especially of artefacts built after the World War II. Usually, these systems degrade the landscape quality because they are built only as a machine, not with a correct design approach to architecture and landscape quality. Then, what is the correct design solution (colours and materials) for environmental quality? What is the colour design approach in different cultures and geographical areas in Europe? The paper will explain the analysis through a significantly case studies group and define some guidelines for an innovative design in the reclamation architecture of Po Valley.

COLOURS AND MATERIALS OF HISTORICAL RECLAMATION BUILDINGS

In this research field, reclamation constructions can be classified into broad categories that identify the plant functions: pumping stations, hydraulic supports, water towers and small artefacts where shall be installed the control panels for hydraulic system, built along the banks of the canals. These categories include the most representative buildings such as the historical or contemporary headquarters and the pumping stations building envelope. The managements of some Reclamation Consortia have observed the great difference between the architectural design of buildings and artefacts built in the Italian country and the same constructions built in other European countries, with innovative design, new technologies and materials. In a special way, this gap is more evident in the buildings built in Italy in the second half of the Twentieth Century. The artefacts built in the first half of the Twentieth Century are characterized by modularity and proportion of the façades: by rhythm, façade texture and the use of materials (size, texture, laying etc.) such as brickwork and stone. The colours of the architecture of reclamation landscape in the early Twentieth Century are the colours of natural materials: red brick, white or pinkish stone, black or grey paint of the mechanical equipment of the plant (the facilities of the first industrial revolution were produced into unique pieces in iron casting). Some interesting examples are the hydraulic station of Cà Vendramin (now Museum of Reclamation Systems) and the plant called “Chiusa di Ceraino” located on the Adige Valley, which is still active.

Looking at the artefacts built in the second half of the Twentieth Century is possible to observe a worsening building design, especially as regards the headquarters and pumping stations buildings. Currently, these artefacts are designed as anonymous building envelopes, without a specific design and identity study: it lacks the design proportions, the architectural design, the integration and dialogue with natural landscape, the cladding design by colours, materials and textures. Usually, the artefacts are built on a rectangular plan, the outer walls are rough plastered or painted with white paint and the roof is pitched and covered with tiles or grey corrugated metal sheets. Also, the external area is used as parking and manoeuvring area, without a design of paths and relaxation areas (seats and other) by a design approach to colour and light technology. They look like warehouses areas.

COLOUR AND TECHNOLOGY OF CONTEMPORARY RECLAMATION BUILDINGS

The selected case studies were classified into two types: the artefacts for pumping stations and the "hydraulic supports" (they are hydraulic structures placed over the irrigation canals, similar to little bridges). The research aim was to draw up guidelines for a new design approach to these buildings by colour and light technology culture to improve the environmental quality and the interaction with the surrounding landscape. As a general rule, there is not design approach in this regard.

Hydropower plants and pumping stations that were analysed are distributed largely in Europe, especially in the Nordic countries (Germany, Netherlands), some plant is located in England, Spain, Italy, South Tyrol, a few cases in the United States or in the Eastern countries. This spatial analysis showed a different approach to the cladding of the artefacts, to the texture and colours based on latitude and design culture. As a general rule, the envelopes of these artefacts were built almost always by dry building techniques, with steel structures and glass, metal or wooden cladding. In some cases, the walls are made of cast concrete. In this situation, therefore, the colour that identifies the artefact and the place remains light grey with a smooth surface. An interesting example is the Punibach hydroelectric power station by *MONOVOLUME Architecture+Design*, built in Mals (fig.1). “The power station is conceived as a fracture in the landscape. Harmonically integrated in its surroundings, it suddenly breaks it open and reveals the machines in its interiors, which serve to transform natural powers into useful energy. The concrete slab, rammed into the ground, separates the smooth hilly landscape and the raw building structure made out of natural, earth coloured materials. By night the appearance changes radically. Whilst the landscape disappears in the darkness, the power station glows through the lamellar façade and presents itself as a landmark to the viewers over the road”.

Figure 1: Punibach hydroelectric power station (ph.© MONOVOLUME Architecture+Design).

In the project “Where the water rest” by Nexus! Associates, in Trento (Italy), the artefact communicates with the landscape through a fusion process between natural and built environment, expressing the will to define a new "landscape" through architecture. The extreme simplification of the volume brings up the grey envelope, which represents the link between the interior (water container) and the exterior (nature), between the artefact and the landscape. This connection is achieved through the envelope texture, made with OSB shuttering that creates light / dark plays on grey surface (fig.2).

Figure 2: “Where the water rest” by Nexus! Associates, colour study in different seasons (ph.© Nexus! Associates).

On the contrary, the small Hydroelectric Power Station near Winnebach brook in Dörfl (fig.3), “is conceived as an artificial rock quarried out of the slope. This sensation is underlined by a very reduced use of materials (concrete, glass and steel) in their rougher form, as well as by the "veins" which cross the volume. These "veins" consist of light bands of layered glass and run around the building. At some specific points of those light bands a normal single glass delivers insight to the power station's bowels. The main building material is watertight concrete, which was pigmented with white mortar and after treated with hydraulic jet in order to achieve a raw appearance.”

Figure 3: Hydroelectric Power Station, colour study day and night (ph.© MONOVOLUME Architecture + Design).

Thus, in general, when the wet construction technique is linked to contemporary techniques, it is usual to use the material in its natural state, free from cladding and colours, as the concrete panels with different natural textures. This is possible using different shuttering materials: metal, different wooden panels, and so on and/or by painting the internal shuttering surface with film/paint for a natural decorative surface. For example, some types of smart paint are used to realize a chromogenic concrete surface. Anglo-Saxon countries have a different approach to this design field: there is a widespread use of steel frames and clear glass panels. In projects such the London Olympic by John Lyall Architect or in the pumping station of St. Germain (fig.4) the systems are exposed. The building envelope is only a transparent limit in a dialogue with the landscape, without damaging it, visually disappearing during the day between the reflections of the surrounding environment. At night the lighting system highlights the existence of the building and exhibits to the place a symbol of the post-industrial era. In this region it seems that the project is still affected by the influence of the industrial revolution and the modernist movement.

Figure 4: St. German Pumping Station, environmental colour reflection (ph.© A.Piva).

The Nordic countries, Germany and the Netherlands for the most part, are relying more on the colour of natural or artificial materials and on opaque textures. In this regard, a remarkable intervention is the artefact built in Cologne, the Flood Water Pumping Station designed by Kaspar Kraemer (2008). The building, consisting of a metal grill and glass façade, is illuminated within by a LED system with variable colour according to the water level of the river. When the water level is normal the light is white, when the water is at alert level it turns red. The light is projected on the transparent walls of the building that becomes a landmark on the river, but also a sign of security for the city. Other projects disseminated in Germany and the Netherlands are characterized by metal claddings. In this case, the goal is always to integrate, with different approaches, the building in the natural or man-made context. Sometimes it has been used an aluminium cladding in grey colour or mirror-treated stainless steel in urban centres. In both cases, the colour and surface treatment adapt the building to the grey colours of the city and of the asphalt. The mirrored treatment reverberates the surrounding environment, making the building completely disappear. When the artefact is located within a natural environment, the cladding adapts to it and tries to integrate it visually. Here the colours are the ones of burnished Corten steel, green roofs or wooden slats.

RESULTS AND CONCLUSION

From the analysis summarized here emerges a highly innovative approach to new artefacts for the reclamation architecture, in an international context, in which the project and the technology adapt to both new building techniques and new materials and to the consequent problems of management and maintenance of the same and, above all, to the landscape. The water system in Italy seems to have been designed only for itself, it does not interact with its surroundings, there is no attention to the project, just to the functionality of the machine. In the European culture, there is a greater focus and collaboration between the skills involved in the project and greater environmental sensibility. In addition to dry building techniques, materials that are adopted are aimed to integrate the artefact with the environment, imitating its colours, but with contemporary technologies. There remains the problem of the interventions on the existing constructions, to enhance and redevelop those artefacts disseminated in the lowlands and Italian landscapes that have a poor dialogue with the context, and often they disfigure it. In these cases we are analysing various assumptions, for example non-invasive interventions, low cost, made with paint or adhesive coatings that exploit the chromatic potential of these materials to redevelop sites. They can also be photo luminescent or dichroic paints or lighting interventions on historical buildings to enhance their presence and identify an area with landscape law bonds. Thus, the colours in the contemporary reclamation architecture show us two different approaches. Many projects had the same historical approach reflecting the natural material colours, but now by the use of new technology and techniques: grey, white, brown and green. This design approach is typical of south/central Europe. In many other situation it is possible to see an high tech approach by the use of innovative materials (metal, glass, glass reinforced concrete, paints, etc.) and light technology. In this case the colours are linked to colour changeable lighting and the landscape reflection on the glass or aluminium facades.

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Urban Design: Colour impact in the human sense of comfort and well-being

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ABSTRACT

The user experience is important in urban design, and the experience must contribute to the user's sense of comfort and well-being. How to define well-being? How does colour contribute to qualified experience? How does colour contribute to the user sense of well-being?
This paper aims to establish that each colour applied in the urban space has a direct impact in the user's physiological and psychological system which contributes for the user's sense of comfort and well-being. The choice of a chromatic palette, considering the building but mostly the set of elements that perform urban space is a way to humanise the places we interact with. With the literature review we expect to identify some guidelines which can be considered / applied by professionals, municipalities and individuals to change the confusing colour language that overcomes in so many urban areas.

Keywords: *colour, urban design, human sense of comfort and well-being, user experience, place humanising.*

INTRODUCTION

> *"The dimensions of colour are many…Colour affects environments, forming and transforming them. In towns and cities it confers magic to everyday life and experience… A vital urban environment is one in which the visual elements – light, colour, and architectonic form signify and express civic functions…. Absent coherent, stimulating, and meaningful environments we risk becoming impoverished, alienated and deprived."* (Swirnoff, 2000, p. IX)

The fast development of the cities has brought up a complex multifunctional scenario which raised liveability and legibility problems. The proliferation of cars encouraged significant distances between work and dwelling areas repeatedly while disturbing the sense of relaxing walk and interaction between user and the potential place' spots. When many people feel disconnected and disoriented, how to qualify the users' experiences in the urban environment in the working, dwelling and entertainment functions?

Provide "*the necessary clues and environmental information that help people orient themselves and intuitively find their way*" (Gibson, 2009, p. 6) is the new challenge of the contemporary urban design. The awareness of this reality leads to the need to deliver the urban space to users. As established by urban planner Jan Gehl (2010), cities need to be humanized returning to the people's appropriation scale. The user experience is important in urban design and the experience must enable the sense of belonging, comfort and wellbeing. New 21st century urban paradigm is not just about form, it is rather about how form supports life.

To accomplish this goal several policies have been implemented. For example, the Scandinavian countries identified their own urban values in the fields of sustainability, creativity, trust, equality and openness, to establish the city planning measures that further inclusive, health, resilient, green, mobile, low-carbon, economics, smart and design priorities. (Nordregio, 2017). In Portugal the improvement of the public space and sustainable mobility measures are prominent subjects. The new city plans try to provide the best routes for pedestrians and cyclists by resolving altimetric barriers and reducing the speed of cars through materials' manipulation in denser areas. To respond to the increase in tourism, the program "one square in each neighbourhood" promotes new leisure places and new ways of displacement. In this context, to the purpose of this article we highlight pedestrian areas as well as revitalization of public space and amenities, as a mechanism to promote wellbeing.

Since the last decade new concepts and research projects have sought to answer to the city's problems. Expressions, such as "walkability" (Speck, 2012), "happy cities" (Montegomery, 2013), "new slow cities" (Powers, 2014), "smart cities" (Albino et. al, 2015) or "cities for the people" (Gehl, 2010), show the emergence of the new humanistic trends with obvious consequences in urban planning strategies.

Despite the conceptual framework, we still lack this desired urban humanism operational measures. The correct use of urban colour may be one of these measures. Through the stimulus of perception colour has the power to influence human behaviour. For this reason, it can be applied to regulate the use of space and to confer quality to the urban experience, connecting functions to colours and its impact in the user's sense of comfort and wellbeing.

However, the colour that characterizes the place is often neglected. Even when we talk about urban colour plans, those instruments only consider the colour of the building façade based upon the historical context. But everything else has colour, urban furniture, street pavements, green and surroundings become difficult to identify through a confused colour language. The choice of a chromatic palette, considering the building but mostly the set of elements that perform urban space is a way to humanise the places we interact with. The awareness of colour impact in the human sense of comfort and wellbeing while experiencing the urban space implies a new approach towards its planning: for buildings, street, urban furniture, equipment, etc… to convey its language to define functions, to orient a route, to spot a detail, to invite to stay on a place or just continue the path.

Therefore, this paper aims to reflect about what defines the sense of comfort and wellbeing for users while experiencing urban space. Furthermore, which is the colour impact on the human sense of comfort and wellbeing?

THEORY

How to define wellbeing?

There is no consensus about the construction of the concept of wellbeing. Assuming a holistic approach, it is possible to state that the sense of health and wellbeing results from a combination of physical, social, intellectual and emotional factors. Such a holistic perspective can easily be illustrated by the Maslow pyramid (Maslow, 2013), in which the hierarchy of individual needs ranges from basic and physical responses, acceptance in the community, to happiness. As far as the feeling of wellbeing of an individual (or a group of individuals) is concerned, how is it possible to relate it with the built urban space? Well, it depends on the experience that this geographical space offers and on the user.

At a first glance, it is easy to state that to offer a qualified experience to the user, the urban context must have quality. But how to define a qualified urban environment? Different approaches can be made to this issue oriented towards a sustainable perspective, considering environmental, social, economic and cultural contexts, and each one can be shown throughout planning actions. Blewitt (2008, p. 163) claims that 21st century came with a "New urbanism" concept that "(…) *recognizes that social and environmental problems need to be dealt with together and has explicitly linked a variety of social goals with optimum urban form.*" These sustainable approaches are the support of concepts such as smart and friendly urban environments. Practical policies to the improvement of urban environment quality led to the management of air pollution, noise level, traffic density (World Health Organization pollution guidelines); the increase of pedestrian and leisure areas to people walk, rest and stay. Porteous (1971) described the quality of urban environment as an intricated question supported by subjective perceptions, approaches and principles which differ among groups and individuals; Pacione (2003) argued that urban environment quality reveals a subjective definition, once it is built upon the place, time and objective of the assessment, and on the assessor's value scale. This reasoning meets the idea that the quality perceived by the user is beyond the quality of the parameters of the urban environment; in fact, the urban environment is perceived by the user in the interactions allowed and boosted along the experience. Based on these arguments it is possible to state that consciously or unconsciously, the user, according to the offered experience, assesses continuously the urban environment in its environmental, social, economic and cultural aspects.

Koppec (2012, p. 51) argues "*there can be no knowledge without emotion. We may be aware of a truth, yet until we have felt its force, it is not ours. To the cognition of the brain must be added the experience of the soul".* Knowing that the user experience is composed by perception, cognition and emotion, how does urban environment fulfil this equation? Perception is the way individuals relate with environment, and individuals perceive environment throughout their senses. What the user perceives from their senses permit to understand and predict context, in other words the performance of our senses build up our knowledge and expectations about urban environment setting (Denworth, 2014). The senses of touch, smell and taste offers information on haptic space, while vision and hearing delivers information about objects or events at longer distance. Cognition is the process of building knowledge throughout senses and/or experience which lead to an emotion. Experiencing urban environment is giving opportunities to our senses to be stimulated.

Knowing that the user experience in the built environment can be qualified according to the stimulus of the five senses (although there are seven), it is recognized the importance, prevalence or dominance of the visual sense. In fact, for the individuals with the vision sense, the majority of the information they have from the outside world is by visual stimulus.

How does colour contribute to a qualified experience? How does colour contribute to the user sense of wellbeing?

"White is considered a safe choice (…) gray will fall into the same category. But it does really justify aesthetically and psychologically sterile environments?" (Mahnke, 1996, p. 82)

Colour is a crucial element to the understanding of the built environment, without colour, built environment would be dull and depressing. Colour emerges as perceptual property and performs an important function within the spaces we live, work and play in. It can induce a dramatic effect in shifting and refining the aesthetic spell of particular areas (Porter, 1976). Colour can attract our sight to a path, a street, a building, an urban equipment, urban signages, etc... Colour perception relies on the light that reaches the object, objects' characteristics such as finishing (textured or polished), the coloured framework nearby and individuals' features.

Colour informs and deceives about the form, dimensions and proximity restrictions. The awareness of these assumptions should lead to a conscious and effective appliance of colour in urban surroundings. However, colour is still an authorial statement, due to the features of the materials used in the façade finishing, furniture and equipment of urban design, pavements, trees, etc.… Recurrently, the colour and finishing material selected respond to contemporaneous trends (Mahnke, 1996) underestimating the impact that colour can have to the reading of urban surroundings or in its physiologic and psychologic effects in the human being. From achromatic to coloured façades and urban equipment, the objective to spot or to mimic a form results into a noisy amalgam without any added value for the urban environment or for the human understanding.

For an effective colour palette appliance, issues such as geographical orientation, amount of light and, the responsiveness to the fact that the urban environment is composed of blocks, buildings, features such as building frames, urban furniture and equipment, pavements, green elements must be observed. Most of studies about urban colour palettes are oriented towards historical areas, where the construction process and thus the original colours aim to be preserved; several analyses of these areas are oriented towards construction processes and materials, observed in a bi-dimensional frame where façades and related elements are the main and only elements of the study. However, all urban areas deserve a colour study towards the safety and wellbeing of users.

The human being can distinguish many colours, tints, shades; thus, the human being is not supposed to experience an achromatic environment in daily routines. Our built environment should offer a colourful experience spotted by a jigsaw of light and shadow, creating the background of the scenario that we engage with, are comforted by, mesmerized or just supported by while developing a function. (Mbina and Edem, 2015)

The impact of colour in human wellbeing relies on how colour can enhance the human/user's experience while experiencing urban or interior environments. Colour awake senses, guides the eye, drives the intention and behaviour while building up the understanding of viewing and/or experiencing a place. Throughout colour and light it is possible to understand distances, proximity relationships, produce identity and define the hierarchy of elements that comprise the scenario where we interact with people and things.

If colour is such a significant issue, as established in the literature review, and it is an issue known by the multidisciplinary professionals who intervene in the built environment then, why is it so negligently applied? If any conceptual project must be submitted to municipal entities which assess the functionality, safety and inclusion of the solution delivered, what is happening with finishing materials and their related colours? Is there any good practice guideline or restriction? Is the choice solely dependent on author preference? Is it required any chromatic analysis along with technical drawing pieces on the submission of the conceptual solution in municipal entities?

DISCUSSION AS A POSSIBLE CONCLUSION

Notwithstanding the significant literature review approaching the subject of colour and urban environment, there is a gap regarding the municipal (or heritage) entities regulatory guides that consider the issues approached by literature review towards a responsive appliance of colour in urban environment. The requirements of official entities often rely on the maintenance of the initial colour, or on the statement of the new colour must be balanced with the environment it is inserted in, without any operative permissions or restrictions to achieve such balance. The balance between a coloured facade with the surrounding environments is a complex concept. The expected harmony does not depend exclusively on the colours' features (such as hue, lightness and saturation) but also from the size and shape where the colour exists. The result is the maintenance of a safe colour palette which persistently characterizes the urban environment with a combination of a certain number of colours or the finishing materials that offer to the building on itself a contemporary look despite its date from the trends of materials applied. We do agree that the regulation of urban environments chromatic palettes must rely on a good practice approach defining the favourite and the permitted set of colours (not just one colour or a single-minded colour composition), applied by the municipal or related entities which, due to its nature, should have all the information that offers the identity of the community and its urban environment, and thus a more integrated vision of surrounding and the impact of a new intervention in the urban tissue.

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A Comparative Study on Consumers' Comfort and Behaviour in Real Furniture Store

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ABSTRACT
This study adopts Mehrabian-Russell Stimulus Response model to real retail furniture store. Comfort level of customers' is measured by exploring emotions. This study uses PAD (Pleasure, Arousal, Dominance) scale questionnaire and observation method to understand behavioural intentions. The experiment was conducted in a real furniture store. Two different colour temperatures, warm white (2700K) and cool white (6500K) were located. General lighting conditions were kept same and LED track spots were used on specific living room furniture set and these two colour temperatures were used on these LED track spots. Total number of twenty people with equal numbers of women and male participated each participant was evaluated in terms of the total amount of time spent in the illuminated environment. Participants were asked to fill PAD questionnaire sheet. Results shows that pleasure level increased when the specific area illuminated with warm white (2700K) colour temperature. Additionally, people spent more time when the furniture set illuminated with warm white.

Keywords*:* *lighting, colour temperature, emotions, behavioural intentions, retail store*

INTRODUCTION

Shopping takes huge parts of people's daily activities. It is obvious that designing commercial spaces is crucial for benefits of market owners and people's comfort while they are shopping (Schielke, 2015; Summers & Hebert, 2001). Since "atmospherics" defined as a marketing tools, that are environmental stimuli affecting feelings and buying behaviour in commercial spaces, many designers and researchers has been interested the impact of atmospherics on consumer behaviour (Quartier et. Al, 2014).

Previous studies are mostly used virtual environments, some of them consider restaurants and many of them used food markets as an experimental space (Ng, 2003). The main difference of this study is usage of a real furniture store environment and real customers as an experimental setup. Also, all lighting equipment is preferred as LED lights because of their sustainable characteristics. LED strip lights used as general lighting equipment and coloured track spot lights (2700K and 6500K) located on specific furniture set.

The aim of the study is to analyse the effect of colour temperature on consumers' behaviour and emotions in real retail store under different accent lighting conditions with the understanding if accent lighting have an impact on emotions and behaviour of customers. Following hypotheses are set to achieve this aim; (1) pleasure level and colour temperature are not independent from each other and people feel more pleasure under warm white colour temperature, (2) arousal level, dominance level and colour temperature are independent of each other (3) People spent more time in front of the furniture set that illuminated with warm white track spot lights.

METHODOLOGY

1. Case Study Settings

The furniture retail store is in Etimesgut, Ankara, Turkey. The shape is not a strict square or rectangle. Total area is 160 m^2 and the height is 3,5 meters. Track spots are shown on Figure 1 and illuminated furniture set is shown in red rectangle (Figure 1). Ceiling is painted with white colour, columns are covered with grey marble and walls are painted with light grey colour.

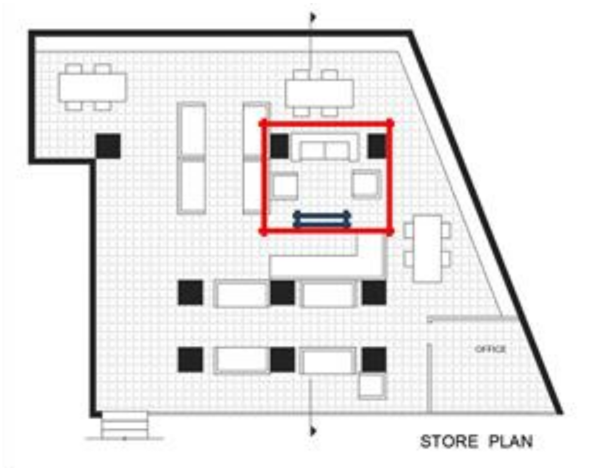

Figure 1: Plan of the store.

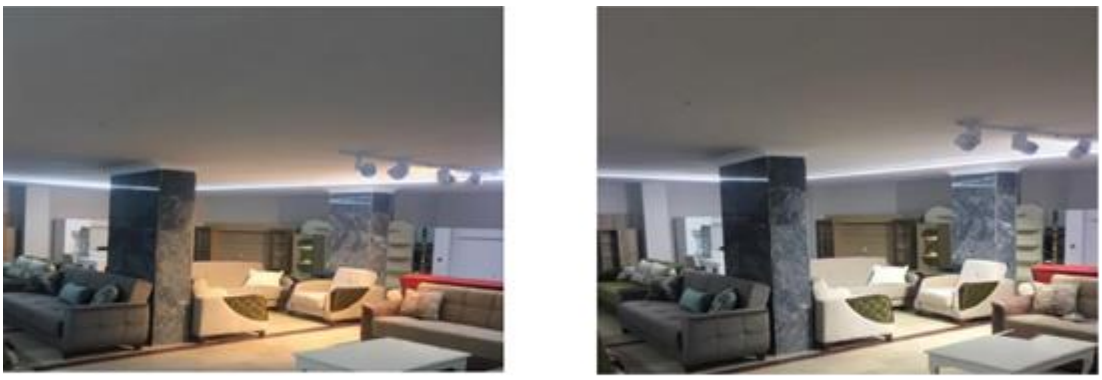

Figure 2: Furniture set under 2700K warm white LED spots (left side) and furniture set under 6500K cool white LED spots (right side).

In this experiment, general lighting conditions of the store is applied with 5000K temperature LED stripe lights. LED track spots are preferred 2700 K, 36 watt and two pieces and 6500K, 36 watt and two pieces (figure 2).

The colour and the shape of furniture set kept same. The colour is S 0502-R in NCS catalogue. Thus, in this experiment, the colour of furniture set and the colour of lighting are independent variables that are controlled by observer. Emotions of people, time spent in store, number of items that are touches and walking directions of customers are considered as dependent variables because they are thought to be changed by independent variables.

2. Data Collection and Analysis

Observation method and questionnaire sheets are used for data collection. Time spent is measured with observation and PAD questionnaire emotion test is used as questionnaire (Mehrabian & Russell, 1974).

IBM SPSS Statistics 24 program is used for statistical analysis. T-test for independent samples test is used for analysing the results. These tests used to compare means under different lighting conditions and results that if emotion levels and lighting conditions are independent from each other or not. Also PAD mean results shows that how increase or decrease emotion results under different colour temperatures.

3. Sample Group

As the experiment conducted in a real furniture store setting, participants are real customers. Experiment was hold after 5 p.m. since daylight conditions is wanted to eliminate. Total amount of 20 people with same number of women and men are participated in this experiment. The mean age of participants is 33, ranging from 18 to 54.

RESULTS AND DISCUSSION

Two independent variable T-test results prove that hypotheses are confirmed. Pleasure level is dependent on colour temperature but arousal and dominance levels are independent from colour temperature.

	Sig.	df	sig. (2-tailed)	mean dif.
Pleasure	0,034	18	0,000	5,589
Arousal	0,882	18	0,340	-1,101
Dominance	0,372	18	0,523	-0,707

Table 1: Two Sample Test Results in SPSS.

Results in SPSS program show that Pleasure level is the only one that depend on colour temperature (Table 1). When mean values are evaluated, people feel more pleasure under warm white colour. In this study there is no significant change on arousal level although some references also mention that Pleasure and Arousal scales are generally both affected by colour temperature (Bohl, 2012; Lombana & Tonello, 2017; Quartier, Vanrie, J., & Cleempoel, 2014; Tantanatewin & Inkarojrit, 2016).

The fact that, mean values for both two temperatures show that people spent more time under warm white spot lights (Table 2). In this experiment, general lighting temperature is 5000K since it could create a contrast effect, people could recognize warm white colour temperature (2700K) easier than cool White light (6500K) as Egan & Olgyay (2002) mentioned, contrast provide easy visibility for objects.

	Temperature	N	Mean	Std. Deviation
Time	Warm White	10	11,22	5,518
	Cool White	10	6,09	3,113

Table 2: Time Spent Mean values.

CONCLUSION

As a conclusion, people found warm white colour temperature (2700K) more pleasurable when it compared with cool White colour temperature (6500K). Under warm white track spots (2700K) people spent more time when general lighting condition is 5000K.

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100 Silesian colours and patterns. Project of decorative patterns and sets of colours inspired by applied art of Upper Silesia

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ABSTRACT

The Project of Decorative Patterns and Sets of Colours inspired by Applied Art of Upper Silesia is a design created within the framework of scholarship from Fund for the Promotion of Creativity of the Ministry of Culture and National Heritage in Poland. The main objective of this project was digital documentation of chosen national heritage with regard to ornamentation and colouring, design of patterns and sets of colours, obtaining graphic materials of high visual quality, possible to be applied with contemporary media. The key results of the project are the database of graphic elements, including set of patterns inspired by catalogued decorative elements and set of colours inspired by typical combinations of colours used in applied art of Upper Silesia. Created elements (described in NCS, Pantone, CMYK, RGB) can be used as elements in many identification projects and be element of visual culture of the region.

Keywords: *Digital documentation, ornamentation and colouring, project of patterns, sets of colours, national heritage*

INTRODUCTION

The project was created within the framework of scholarship from the Fund for the Promotion of Creativity of the Ministry of Culture and National Heritage in Poland.

We are convinced about the need for preserving and promoting the cultural heritage of the Upper Silesia region in all its variety. Upper Silesia is an industrial area developing dynamically since the late 19. century. It is famous for coal mining, metallurgy, but also for the production of ceramics and utility glassware. For the region of Silesia today, culture constitutes an important element of economic development increasing the competitiveness of the area.

So far, however, the applied art of Silesia has not been documented with reference to its colouring, ornamentation, decorative elements, which are unique and characteristic of this region. As the Second World War and further political turmoils of Polish history caused the demise of important manufacturers and works in Silesia, the industrial designs and pieces of decorative arts at the pattern shops were not archived. Most of catalogues and technical specifications of patterns were lost or destroyed. Today, the institutions for protection of folks art frequently do not dispose of digital documentation of sets of patterns and ornaments.

The archiving to date has been conducted individually and to small degree, and resulted in publications either on selected objects (such as stain glass, ceramics, architecture) or, rarely, in reference to the output of one industrial works. The elements of colouring and ornamentation typical of the whole region have not been described yet.

The project assumed that it was possible to develop sets of colours to define colouring trends as well as groups of patterns reflecting the visual and cultural character of the products of Silesian manufacturers. Parametrization of colours provides information about these items and may help unclatter the nomenclature used for their description. The sets of colours is a public and user-friendly visual tool, which can be used for information and promotion of folks art and industrial heritage of the region.

Our activities focused on archiving the existing patterns and accompanying sets of colours, and designing projects inspired by original motifs. The resulting visual database consists of vector projects (in digital form, to be printed, plotted and processed by means of computer tools and media) is public and available for promotional purposes.

THEORY

The research involved a series of field trips and interviews with experts on folks art and post-industrial heritage conducted in order to mark out a collection of patterns representative of the Silesian applied art.

Institutions invited to collaboration included several museums (Museum of Upper Silesia in Bytom (1), Museum in Rybnik (2), Silesian Museum in Katowice (3), Ethnographic Museum in Opole (4), but as it turned out, their collections do not include any craftsman or mass produced objects of the period 1900–1990. In the majority of cases, they were claimed “not vintage enough.” We managed to select several patterns of handmade ornaments on ceramics of the late 19. century from the collection of Museum of Upper Silesia and handmade ceramics from Ethnographic Museum in Opole. Another element of the project were the ornaments on enamelware, manufactured by Silesia Steelworks. This collection was partially composed of objects included in the exhibition “Huta Silesia Design” – Silesia Steelworks Design, another one was composed of scarce catalogues of patterns from private collectors.

Taking the industrial designer’s perspective – it was not possible to do all the complex and detailed ethnographic analysis. Therefore, I focused on such formal elements of craftsmanship produce which seemed important due to noticeable consistency in reference to ornamentation and colouring of the objects. As a result of consultations with experts, ethnographers, collectors and advocates of Silesian craft, I selected several hundreds of ornaments – decorative patterns on ceramic and enamelware produced in Silesia in the late 19. and the early 20. centuries.

Working with Ethnographic Museum in Opole, I managed to organize consultations and workshops with folks artists and through that build a broad context for the project, as well as mark out the disciplines of folks art representative of the whole cultural phenomenon in question (5).

EXPERIMENTAL

The first stage of the research was to build an image, a visual interpretation of the phenomena in question and the regularities of colouring, as well as to define the features characteristic of the regional ornaments.

Parametrization of selected elements of colouring and ornamentation consisted in photographic documentation and sampling of particular colours. Most of the time it was possible to access the exhibits directly, therefore the sampling of colours could be made by means of testers and NCS tools (NCS Colour Scan), as well as the Pantone testers. Each of the selected colours was described in several systems, such as Pantone, NCS, CMYK, RGB, in order to make the set of colours supportable for various media and graphic applications – it ought to be as useful and user-friendly as possible.

Reproduction of ornaments and designing the patterns inspired by the catalogued decorative elements involved working with vector graphic programs (Adobe) based on the gathered visual materials.

The most difficult issue that became apparent in the process of digitization of patterns, obtained from the prepared materials or those provided by the museums, was the significant variety of ornaments. The motifs on porcelain had been made by means of numerous techniques, including decal, enamel, hand-painting and scratching. The decorations varied from the graphics point of view, and it was a priority to maintain their distinctive character while digitizing the patterns. It was therefore necessary to approach each of them individually. Consequently, no automatic vector tracing tools, available from graphic programs, could be used. Decals and enamel patterns were usually created by outlining them with a pen or painting by means of the "brush" tool, as it facilitated obtaining the elements of irregular shapes. The hand-painted decorations, on the other hand, were created on layers provided by the raster graphics program. Brush painting not only enabled higher precision, but also helped to imitate the trace of original tool. Next, all the layers were transformed into vector objects, coloured and properly arranged.

Figure 1: Process of digitization of graphic motifs.

Another challenge was the quantity of elements. As easy as it was to create patterns composed of repetitive elements and structure resulting from obvious arrangement of base components, the motifs akin of illustrations were much more difficult and time-consuming.

The following stage of work was making sets of patterns inspired by the cataloged decorative elements. With the closest possible attention to the intrinsic structure, each of them was presented as: original pattern, strip pattern, pattern described on a wheel or oval, and report / square field containing repetitive elements for free multiplication.

There was a certain latitude in composition of particular visual elements of patterns, some of which were scaled, multiplied or minimized. As far as graphics is concerned, however, the value (style, characteristic outline and inside) and original colors of the ornament had been maintained at all times.

All of the developed patterns are included in the album "Silesian colours and patterns. Project of decorative patterns and sets of colours inspired by applied art of Upper Silesia" available in form of e-publication from the collection of the Silesian Digital Library (6).

Figure 2: Selected patterns developed on the basis of digitized graphic motifs.

Figure 3: Selected patterns developed on the basis of digitized graphic motifs.

RESULTS AND DISCUSSION

Among the most significant results of this project, I would name:

1. Digital documentation of chosen national heritage with regard to ornamentation and colouring.
2. Developing patterns and sets of colours inspired by the applied art of the region.

Obtaining graphic materials (patterns of ornaments, characteristic sets of colours) of high visual quality, possible to be applied with contemporary digital media and making use of heritage of decorative art in creative, modern and innovative ways.

3. Bringing back the social awareness of original decorative elements connected with the history, culture and identity of Silesia, as well as promoting and building the image of this region through the contemporary applied art.

CONCLUSION

As this collection has been made available as open source, the new patterns and sets of colours may be used in graphic projects promoting Silesia by means of visual materials (publications, diplomas, gadgets, elements of overall identities, multimedia visualizations), expositions in the public space (large-format prints / graphic applications, street art, projections on buildings and squares), as well as templates for open-air workshops and promotional campaigns in the region. The designed patterns and colours were presented throughout Silesia on multiple occasions of local events promoting the regional culture, in order to introduce the whole process of recreating the Silesian colours and ornaments and bringing them back for everyday use.

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Survey on perceived façade colours using colour samples from ready-made plaster collection for southern Poland

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ABSTRACT
The main goal of the article is to present the results of the colour survey, conducted by the authors as a part of the development of a new colour palette of finished façade plasters for the Polish manufacturer Fabryka Farb i Lakierów "Śnieżka" S.A. The key objective of the survey was to examine and define differences between perceived and nominal colour, which may result in improper selection of colours for the façades. For the purpose of the study 12 colour samples with dimensions of 1x1 meter were prepared. The analysis of the results confirmed the general tendency to reduce blackness and increase whiteness level of the colours perceived in relation to the nominal ones. Most of the colours showed a relative hue stability, with the exception of achromatic ones. No significant influence of the changing lighting conditions, nor the observer's experience in working with colour on the sample reading has been confirmed.

Keywords: *colour in built environment, colour in architecture, façade colour, colour perception, colour design*

INTRODUCTION
The colours of single-family houses constitute, in many countries, the basic element of creating the unique character of cities and regions. Its colour palette is the effect of using local materials or the choice of paint or plaster, the colour of which corresponds to local traditions or specific preferences. According to Jean-Philippe Lenclos: "*material samples such as coatings, offer the most authentic testimony of the colour, that characterize the geography of colour of a site or region.*"

Due to the intensive development of single-family housing in Poland after 1989 (the collapse of the communist regime), there was a need for various materials for finishing the façades. Since most of the houses have plastered façades, private investors, most often using typical catalogue designs, choose the colour of the plaster which, above all, suits their tastes and current trends. The choice is quite free in many regions, because spatial development plans often lack regulations for the local colour palette. Inadequate colour selection causes a visual chaos, especially visible in suburban and rural areas. Therefore, even though the technological possibilities of colour mixing are enormous, most companies offer ready-made plaster collections, in order to make it easier for recipients to choose. Examples of popular collections include: Kabe F (206 colours), Kabe K (300), Ceresit Colours of Nature (211), Foveo (240), Greinplast (167), and Majsterpol (120). Due to technological reasons (heating of plaster surfaces under the influence of direct sunlight), the collections predominantly include light colours with a high white content, most of which are shades of yellow and red ochre, typical for the Polish architecture. In recent years, grey has also become very popular, and is gradually replacing the traditional chromatic hues. A crucial problem in choosing external colour for buildings is the difference between the nominal and the perceived colour. The phenomenon can be troublesome both for paint manufacturers and individual recipients who, choosing a colour from a small sample, are often disappointed by the final effect on the façade. The difference is sometimes so essential, that it can become a reason to demand a refund for the plaster purchased. The authors' proposal of a new collection of ready-made façade plasters for the Polish manufacturer Fabryka Farb i Lakierów "Śnieżka" S.A. in the years 2016-2017 initiated the experiment, the aim of which was to examine differences between perceived and nominal colours from the developed palette. The colours used in the survey were selected on the basis of popularity rankings developed by leading plaster and paint manufacturers, based on sales results in Poland in the last decade as well as authors' own research in the field of architectural colour. All colour samples have been described in the NCS notation (Table 1).

The 12 plasters' colours were to represent the most characteristic southern Poland façade colours, both in the chromatic region (1010-Y, 1025 Y10R, 3010-Y10R, 1020-Y30R, 0520-Y50R, 3040-Y70R, 0710 Y90R), as well as neutral (2500 N, 1002 Y50R, 1002 R50B), to which two colours from the group of green and blue were added for supplementation (2030 R90B, 2622 G25Y). As in discussed survey it was only possible to test plastered colour samples instead of real facades, there is no ambition to find coherent and statistically significant patterns. The main objective was rather to compare the obtained results with the previous findings, to indicate the similarities and differences, like for example potential impact of local light conditions and characteristic of texture.

THEORY

The theoretical basis of the study is constituted by the fact, that there exists a difference between colours seen on the façades (so called perceived colours) and the colours chosen for buildings as defined by colour samples (so called inherent/nominal colours). The perception of colours on façades is influenced by a number of factors, such as: the type of surface (rough/smooth, glossy/matte etc.), its size and shape, viewing conditions (light, distance, observation angle, neighbouring colours etc.) and - last but not least - the person of the observer himself. Nevertheless, there is also phenomenon of colour constancy, giving the ability to perceive the colour as relatively constant irrespective of the instant changes in lighting conditions. The issue of the colour perception in the outdoor environments was the subject of research by many scientists – among them Anders Hård & Lars Sivik. However, the most insightful and extensive study on façade colours has been carried out by Karin Fridell Anter, whose research, described in the book *What colour is the red house? Perceived colour of painted façade* (2000), includes about 3600 observations. It is also worth to mention recent study conducted in Warsaw (Poland) by Anna Sochocka with cooperation of Fridell Anter, where the difference between perceived colour as seen from a distance of approximately thirty metres and the nominal colour of the façades was investigated.

EXPERIMENT

The discussed survey was conducted by authors twice - in June (Summer) and October (Autumn) 2017 in Krakow (geographical position 19°58'E and 50°04'N), on the campus of the Cracow University of Technology (CUT). 64 participants took part in it, mostly students of Architecture from CUT and students of Industrial Design from the Academy of Fine Arts.

For the purpose of the study 12 samples with dimensions of 1x1m were prepared, covered with plasters coloured in mass, with the most commonly used texture type “baranek”, which, depending on the aggregate size (in the range of 1.5-3 mm) gives the effect of smaller or larger grain. The plastered samples were hung 30 meters from the observation site, at eye level (~ 1.7m), with a distance of about 1 meter between each board. It was decided to turn the boards northwards, to avoid direct sunlight. Thanks to this, although the study was carried out between 10 AM and 4 PM, the samples were constantly illuminated with scattered light, guaranteeing similar observation conditions for all participants. The boards were hanged on the grid, which gave them a natural, landscape background of trees.

The task of the participants was to find in the NCS atlas colours corresponding to the presented plasters, and then enter their notations into the prepared study forms. This test method was selected based on the work carried out by Karin Fridell Anter, as it gives the opportunity to precisely describe the results using the NCS system tools (triangle, circle). The survey form contain also information on weather conditions prevailing at the time of each session (e.g. full sun, partial cloudiness, full cloudiness, rain). Before the survey the study form samples were sent to all participants by email. They were also asked to check their colour vision using the PseudoIsochromatic Plate (PIP) Colour Vision Test (Ishihara) or Munsell Hue Test. Before the survey all observers were trained in the use of the NCS system, too. Each testing session, lasting about an hour, was conducted in group of 5 people, so everyone had a separate NCS atlas and could work independently of one another. The observers stood in front of the analysed sample, holding the NCS atlas or card removed from it approximately vertically and with lighting conditions as equals as possible to the light on the plastered colour samples. The observer could also look at the sample through colour mask, which gave the opportunity to better isolate the colour from the background and from the influence of neighbouring colours. Each observer had about 1 hour to analyse 12 colours and write down their notations on the study card. There was a place for 2 possible answers, in case when one decision cannot be made. Only two of the observers (authors of this article) knew the nominal colours before the registration of perceived colours.

RESULTS AND DISCUSSION

The results of the study were collected in the summary tables, and then for each of the 12 samples a graphical illustration of changes in hue and nuance using the NCS circle and triangle was made (Figure 1).

For each sample, differences of blackness, chromaticness and whiteness between nominal and perceived colour were calculated (Δs, Δc, Δw) and presented in the Table 1.

nr	colour code/ NCS notation		Δs	Δc	Δw	lightness changes	saturation changes
1	2500 N		-10.50	+4.1	+10.4	+	+
2	1002-Y50R		-3.6	+1.77	+6.63	+	0+
3	1002-R50B		-2.2	+4.46	-2.26	-0+	+
4	140C / 1025-Y10R		-2.67	-3.04	+5.71	0+	-
5	3010-Y10R		-10.1	-1.37	+11.47	+	-0
6	1020-Y30R		-4.07	-5.41	+9.48	+	-0
7	210 C / 1530-Y40R		-5,71	-3,24	+2,77	+	-0
8	0520-Y50R		+1,49	-9,15	+17,5	0+	-
9	3040-Y70R		-8,53	+11,26	+5,70	+	-0+
10	290 F / 0710-Y90R		+1,38	-1,75	+8,00	0+	-0
11	2030-R90B		-9,16	+5,63	+7,74	+	-0+
12	TK 4923 / 2622-G25Y		-6,64	+3,77	-7,29	+	-0+

Table 1: Blackness (s), chromaticness (c) and whiteness (w) average difference (Δ) between nominal and perceived colour in NCS units. Next two columns indicate main direction of changes in "lightness" and "saturation". Minus denotes that the attribute is smaller in perceived colour, plus indicates the opposite, 0 means that the change is minor or cannot be clearly determined.

The nuance differences between the inherent and perceived colour for the samples examined in the survey show the most common tendency to decrease blackness in the perceived colours. The exceptions were 0520-Y50R and 0710 Y90R, when blackness slightly increased. The decrease of blackness generally corresponds with the increase of whiteness, with its relatively high difference between the nominal and perceived colour in case of two yellow-reds (3010 Y10R: Δw +11.47, 0520 Y50R: Δw +17,5).

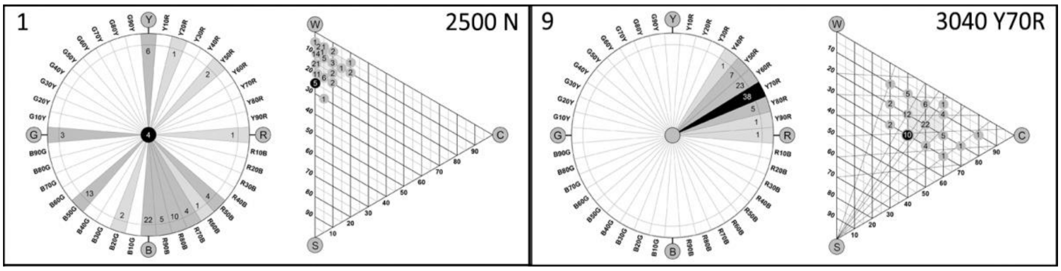

Figure 1: Example of graphical presentation of the results for samples nr 1 and 9 using the NCS circle and triangle (black dots and circle sectors indicates the position of nominal colours).

The changes in chromaticness were not so stable, in one half of the perceived colours the chromaticness increased, in the other a slight decrease was noted. The increase in chromaticity was observed in the case of three colours with the highest saturation (3040-Y70R, 2030-R90B, 2622-G25Y) and greys, in which observers perceived different chromatic shades. After analysing the nuance differences an attempt was also made to find some rules concerning the hue difference. There is a generally known tendency of shifting colours from yellow to blue with the increasing distance from the observer - phenomenon often called an aerial perspective. Karen Fridel Anter used the NCS colour wheel to analyse the hue changes and, according to her findings, this tendency reverses in the area between Y35R and Y50R where the amount of yellow in the perceived colour is starting to decrease. In our survey the changes of hue for the selected colour samples were relatively small. For the green colour from the survey there is a slight hue shift towards blue which means that the perceived colour has less yellowness that the inherent one. It could be caused by the distance from the observers or by the fact that all the colours were assessed on the background of trees and natural greenery.

Inherent colours with yellow hue (1025 Y10R, 3010-Y10R) showed a visible shift towards green. The hue difference between inherent and perceived colour was stronger for the less chromatic colour (3010-Y10R). For nominal colours with more reddish hue (1020-Y30R, 1530-Y40R, 0520-Y50R) there was no clear tendency for perceived colours. Some of the answers showed the shift from yellow towards red and some opposite.

The neutral grey colour (2500 N) tended to give the perceived colours some chromaticness. The most common shift was towards blue (B - 22, R80B - 10 answers) or blue-green (B50G - 13), however 8 observers have noticed some yellowness (Y) in the perceived grey. The average chromaticness difference was +4.1. For the chromatic grey with a slightly yellow-red tinge (1002 Y50R) there wasn't a general tendency in hue change and the answers were scattered around the colour wheel. The third grey (1002 R50B) tended to shift towards blue and the most participants pointed primary blue (B – 16) as the perceived hue. This result confirmed the existence of the so-called "breaking point" near the primary blue colour, where according to Anter the nominal and the perceived hues coincide. However, this phenomenon can be also caused by small diversity of samples in blue range offered by NCS System.

CONCLUSION

The analysis of the results clearly confirmed, also emphasized by other researchers, the general tendency to reduce blackness and increase whiteness of the colour perceived in relation to the nominal one. Most of the colours showed a relative hue stability, with the exception of achromatic colours, which underwent multi-directional changes towards chromatic colours. No significant influence of the changing lighting conditions nor the observer's experience in working with colour on the sample reading has been confirmed.

The authors hope that thanks to information about the directions of changes, the results of the examination, suitably illustrated, may facilitate the more conscious selection of façade colours from the prepared collection of finished plasters.

ACKNOWLEDGEMENTS

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Colour Planning in Town, a non profit colour project

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ABSTRACT

Colour is much more than decoration. This medium definitely influences human beings – consciously and unconsciously.

The IACC Chapter Europe, was invited in 2017 to create a new colour pallet for the City of Lanciano, Italy, maintaining the character and identity of the town.

Eleven buildings of the centre were selected to be worked on. The collected 53 old colour samples were the base for the very careful analysis and the strong reduction to 21 tones of the new pallet.

Finally, various colour collages were produced to show to the mayor, the community and the public of Lanciano the enormous change of impression- using just colour.

Colour is definitely an absolute necessity for a balanced environment

A medical statement published that more than 75% of all illnesses derive from stress: In this connection the stress diminishing property of colour is THE MOST EFFECTIVE one to take care of.

Keywords: *Colour-Planning, City-Identity, Colour and Human Response, Orientation*

INTRODUCTION

Colour is much more than electromagnetic wave lengths and much more than simply decoration, especially when colour is used for architectural purposes or public spaces. And further on, it has nothing to do with short cuts of time trends or personal taste. This interesting medium can be looked at from many, very different points of view as physiology, psychology, personal experiences, colour and human response, medicine, physics, chemistry, colour metrics and colour theory, colour and environment, colour design and colour planning or art, fashion, food, and last but not least, colour and education. All these themes definitely influence us – human beings –

both consciously and unconsciously. Therefore, it is our duty to dedicate the maximum of our attention to these subjects and their effects on human life.

In 2017, the International Association of Colour Consultants /Designers , IACC Chapter Europe, was invited to create a new colour pallet for the City of Lanciano, Southern Italy, maintaining the character and identity of the town.

A "non profit project" was offered to the community of the city. Non profit means, that our knowledge and experience in practice was included in the project, experts and students of our society were working free of charge, compensated for the personal expenses and materials only.

In this presentation I would like to talk about the collaboration between my colleague and IACC Colour Designer, Mrs. Lee Jin Hee and myself.

THE PROJECT

Lanciano, is a small town, situated between very high and often snow covered peaks of the Southern Abruzzi and the blue Adriatic Coast.

Figure 1: Lanciano, general view of the project by Lee Jin Hee.

In the past, due to its geographic location the city flourished and turned into a meeting point of merchants, travellers and pilgrims, coming from all directions. Nowadays, Lanciano became a preferred meeting point for musicians and students, as well as of music lovers, especially because of its famous summer concerts. Every summer, more than 100.000 tourists visit the city. For this reason, the mayor and the community expressed their wish to give Lanciano a new, fresh and more attractive look but still maintaining its character and identity!

First, the community identified the area of the core of the old city, to be worked on and clearly marked up those buildings on a map, which we should combine as a harmonic ensemble.

THE COLOUR COLLECTION

A special guided tour through the old centre was arranged! The explanation of the history of each building, the date of its foundation, the quality of the bricks or natural stone and its enormous variety of colour tones was essential for better understanding the character of the city. Easily, we noted that the enormous space of time between the buildings of the 12th to the 18th or 19th century, and finally ending up with the beginning of the 20th century, which would be a real challenge to combine.

Special difficulties appeared when examining the different materials of the facades, as well as their colours. For example, various shades of natural stones reached from pale yellow grey to deep brown, when wet near the basement. We discovered the same wide colour circle in the colour sequence of bricks: they started with white, continued with yellow, okra and light brown, to finish with tender pink and olive green.

As a next step we started to take colour samples of each building of the selected area with every single detail of the facades.

All elements were examined as the basis, the facade, its décor, gutters, doors, windows, shutters, balconies, railings, and when visible, also the colours of roofing tiles.

Figure 2: Colour & facade by Lee Jin Hee.

Figure 3: Colour sample and mixed colour.

THE ANALYSIS

In my studio in Vienna we started to translate the collected, printed colour samples of the various colour shades into real paint. For this work a local colour producer offered colours for walls and wood in transparent and opaque, silicate and acrylic quality. So it was possible to imitate the effect of old lime paint. As substrate for the paint to be applied, wooden boards, in the size of 30 x 40 cm were prepared.

Finally, 53 colour shades were mixed, mainly whites, white-greys, light yellows and light ochre tones. Interesting to us was the discovery that in the surrounding of Lanciano not only the natural limestone had light ochre or grey ochre colours, but also the bricks. In the 19th century they were used for facades without being covered by plaster. So the main impression of the city of Lanciano – at least in the centre were we worked- was a grey-yellow or pale grey-ochre pallet.

Analysing carefully the plaster and the old paint, I noticed that in some parts of the walls the plaster consisted not of white or yellow sand but of grey, in some parts also dark grey sand.

Therefore, some of the walls looked dirty or full of soot when they only lost their paint, which was washed away over the years. This was the reason why Lanciano gave me the impression of being a sad and abandoned small town.

Three of the examined eleven buildings, except the old 12th century church S. Francesco, are true eye catchers because of their strong colours: the so called " Casa con Sole" (House with Sun, 1920) in Via Roma, the house Via Roma corner Piazza Plebiscito (1730) and the "Palazzo Petrosemolo"(1920).

The "House of Sun" has a narrow but rather high facade of light ochre bricks without plaster. Parts of the facade are covered with plaster and painted in strong yellow-orange ochre colour. There is a great difference between the pale bricks and the very saturated paint. The observer has to pay attention to this building, passing the narrow street, because the houses nearby are more or less white or pale yellow-grey.

The house in Via Roma-corner Piazza Plebiscito, deriving from 1730, called Palazzo Terracotta, because of its terracotta colour. In this case the construction is covered with plaster and painted in two shades of terracotta, a darker tone and a lighter one. But also here, the lighter terracotta is too desaturated to combine well with the rest of the facade.

The dark green colour of the big, wooden shutters is much too dark. If closed, they turn into deep black holes!

And last not least the Palazzo Petrosemolo, built in 1920, is the strongest of all, regarding the quality of its colours: the bricks, probably double burnt clinker are in a very saturated bright red. The shutters of the big windows and doors are painted in a highly saturated turquoise. Although the strong red could be balanced by a complementary colour green, the high saturation does not allow the balance. Further the red facade is divided by three stripes of plaster, painted in a slightly broken but still brilliant greyish white. This colour combination is very noisy and therefore does not take part of the rest of the ensemble.

Another interesting discovery analysing the environment was the brilliant and high saturated light turquoise shutters of the pharmacy, facing Piazza Plebiscito. The facade obviously was painted after the 2nd World War in opaque white titanium. This colour plays an important role for the harmony in the very centre of the place.

When analysing the left part of the southern facades of the Piazza Plebiscito as well as the right one, it was discovered that the single facades were painted in different colours or different shades of a colour. Looking at the left or the right group of buildings, someone gets the impression, to look at many different and small houses. The total overview is very unique but somehow disordered.

For a clear overview which colour appears where, we decided to use the model of a variable matrix for each single building. It helped a lot to clear the situation how to find the right decision for the main challenge - the new pallet for Lanciano.

CONSEQUENCES AND THE NEW PALLET

Starting with 53 colour samples, mixed and executed with the material, provided for the final use, it was clear that this high number of colour shades for only eleven buildings needs to be, first of all, strongly reduced.

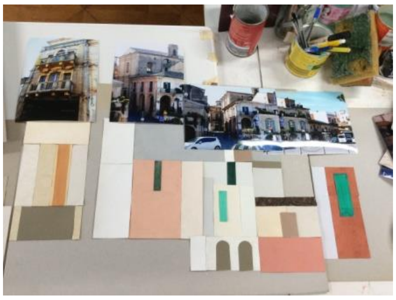

Figure 4: Photos with current colour samples by Lee Jin Hee.

Placing the colour plates together according to the buildings on the map, it was not too difficult to decide which colour shades can be removed and which ones should remain. The general goal was to maintain the actual character of the city and to take its unique identity into consideration. In various working operations, step by step, the number of colours was reduced to 17 samples.

In a separate process, four more colours were added to harmonise the general colour climate. This was especially necessary in the south- western ensemble of the Piazza Plebiscito, from the edge of Via Roma to the Palazzo Plebiscito.

In this part of the city centre, the main colour sequence appeared in grey-whites, yellowish light browns and several light and middle, warm grey shades. At the extreme right edge of the ensemble appeared the Palazzo Plebiscito with its strongly saturated colour sequence, like a remarkable full stop! An eye catcher par excellence!

The real challenge was to integrate the Palazzo Petrosemolo in the colour sequence of the rest of the ensemble. Using the reddish colour of the terracotta house of Via Roma, which was facing to Piazza Plebiscito with its northern façade, also repeating this colour tone on one of the other houses of the ensemble, brought the solution. A light red, but in a cooler version, was also inserted into the left ensemble under the arcades of the 17^{th} century of Palazzo Zecca to connect the red bricks of the ground floor of Palazzo Mariani, deriving of the 19^{th} century with the rest of the total ensemble.

Finally, we directed our attention to the numerous shutters of the door – windows, leading to the balconies. The colour sequence reached from very dark and heavy greens to the highly saturated bluish green and further to the light, but very saturated turquoise. Having got samples of a brand new transparent material for wood, (described as resistant to UV sun rays) a series of colour tests in turquoise-green were executed.

After a number of 21 shades for the various facades of the eleven buildings, we decided on using only one, a maximum of two, turquoise shades to harmonise the new pallet for Lanciano.

CONCLUSION

Figure 5: Collage of current pallet by E. Mally.

Figure 6: Collage of new pallet by E. Mally.

To demonstrate the change of the effect of the new colour pallet to the clients and the public, colour collages with the original colours provided for the final use were executed.

Not using the computer for colour projecting, one avoids the enormous difference between the appearance of colour on a monitor – seen thru the lens - and the final effect of true paint on the wall that can only be seen in reality. This problem seldom is considered as serious, not enough taken care of or taken into consideration. And sorry to say, it is very seldom corrected or adapted to the optical impression and effect of colour sequences. We have to remember that the additive colour matches, in spite of all new technical achievements, never can be the same as the subtractive colour mixture. These two worlds of colour never will meet.

The IACC Colour Academy has focused its activity on education of the responsible use of colour, based on scientific research and practical experience. The power of our seminars is the integration of interdisciplinary knowledge and research into colour planning.

Colour is definitely more than decoration. It is an absolute necessity for a balanced surrounding and the wellbeing of human life. Recently a medical statement was published explaining that more than 75% of all illnesses derive from stress: In this connection stress diminishing property of colour is…

…THE MOST EFFECTIVE one to take care of.

…Therefore, COLOUR is much more than decoration.

AIC LISBOA 2018
colour & human comfort

Spatial colour design using Luminous colour images; Part 1 - how to extract Colour Contrast Images from Luminous colour images

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ABSTRACT

In order to establish a method to estimate colour appearance of various objects in the real built environment, the authors reexamined conditions where colour constancy emerged and suggested that luminous colour contrasts between a colour chip or a subject and its background could estimate its colour appearance, and so that colour appearance could be objectively estimated when we had luminous colour images on an imaginary plane in front of our eyes. To make certain this suggestion, contrast of hue-different colour chips set against N5 background were examined, and by applying filtering, colour contrasts in luminous colour images of Munsell hue circle and those of real townscape were also examined. As the results, colour appearance in the real environment would be reasonably estimated.

Keywords: *luminance image, luminance and chromaticity, image analysis, contrast profile*

INTRODUCTION

Spatial Colour design of the built environment under various lighting conditions is quite difficult except for well-experienced colour designers. This difficulty is mainly caused by difficulty in estimating colour appearance in the built environment, because colour appearance of surfaces in the environment is defined not only by reflectance of them but also by attribute of light illuminating them. Furthermore, there are a lot of luminous or light-emitting objects in the real built environment like PC displays or digital signage displays. In reality colour distribution of the built environment is composed of mixture of luminous colours and reflected colours under different illuminations. As it is, we have two different colour representation systems; one is for object colours like Munsell colour system, and the other is for luminous colours like CIE 1931 XYZ system. In order to realize failure-free spatial colour design, we need an integrated colour specification system applicable to both object colours and luminous colours.

THEORY

To find a possible way to this integrated system, the authors would like to propose dealing with luminous colour images, namely 2 dimensional images of luminance and chromaticity, on an assumed transparent screen in front of our eyes. As shown in Figure 1, the lights reflected on objects and the lights emitted from luminous displays are both projected in the same way on that screen, in other words, there is no distinction between object colours and luminous colours. Problem is that colour perception, as well known, cannot be estimated by just the value of luminance and chromaticity, but can be more or less inferred by reflectance of surfaces. The authors would like to suggest solving this problem by obtaining contrast values in luminous colour images on the transparent screen.

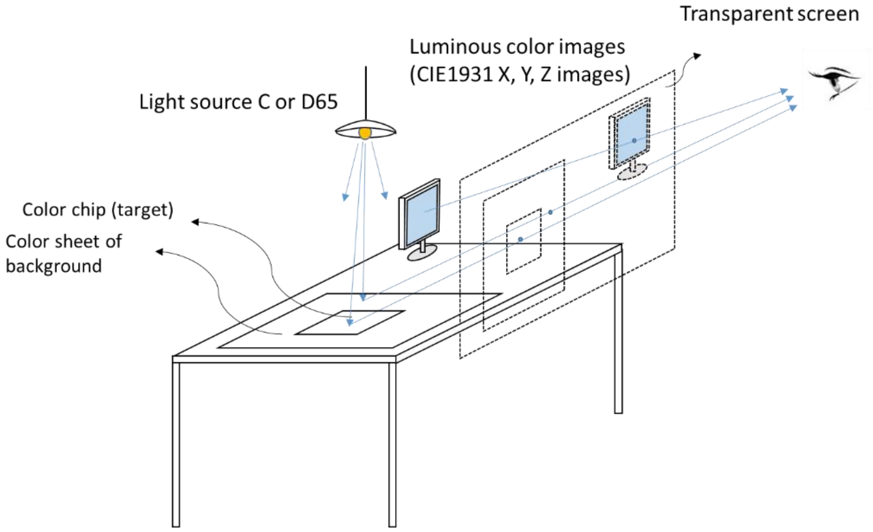

Figure 1: Luminous color image on an assumed transparent screen.

When we see a colour chip, the chip always has its background. For example, as shown in Figure 1, a target colour chip was set on a sheet of background colour paper. The perceived colour of the chip would not vary even when the light source varied from the illuminant C to the illuminant D65, for example. This phenomenon is called colour constancy. In order to simply this situation, assuming X, Y, Z reflectance of the target chip as ρ_{x_t}, ρ_{y_t}, ρ_{x_t} and those of the background as ρ_{x_b}, ρ_{y_b}, ρ_{x_b}, X, Y, Z values of reflected light could be estimated by multiplying those reflectances and X, Y, Z values of the light source. It is true that X, Y, Z values of reflected light varied by change of light source but contrasts of X, Y, Z between the chip and the background was constant and could be calculated by following equations, when X_t, Y_t and Z_t were tri-stimulus values of the target and X_b, Y_b and Z_b were those of the background.

$$\left.\begin{aligned} \rho_{x\_t}/\rho_{x\_b} &= X_t/X_b \\ \rho_{y\_t}/\rho_{y\_b} &= Y_t/Y_b \\ \rho_{z\_t}/\rho_{z\_b} &= Z_t/Z_b \end{aligned}\right\} \text{-- (1)}$$

These equations suggest that color constancy would be able to more or less explained by use of contrast values between the chip and the background.

To understand colour appearance of the target, with reference to CELAB colour space (CIE L*a*b*), the authors defined LC, aC and bC as follows;

$$\left.\begin{aligned} LC &= \log 10\left(\frac{Yt}{Yb}\right) \\ aC &= \log 10\left(\frac{Xt}{Xb}\right) - \log 10\left(\frac{Yt}{Yb}\right) \\ bC &= \log 10\left(\frac{Yt}{Yb}\right) - \log 10\left(\frac{Zt}{Zb}\right) \end{aligned}\right\} \text{-- (2)}$$

LC: luminance contrast, aC: red-green component contrast, bC: yellow-blue component contrast

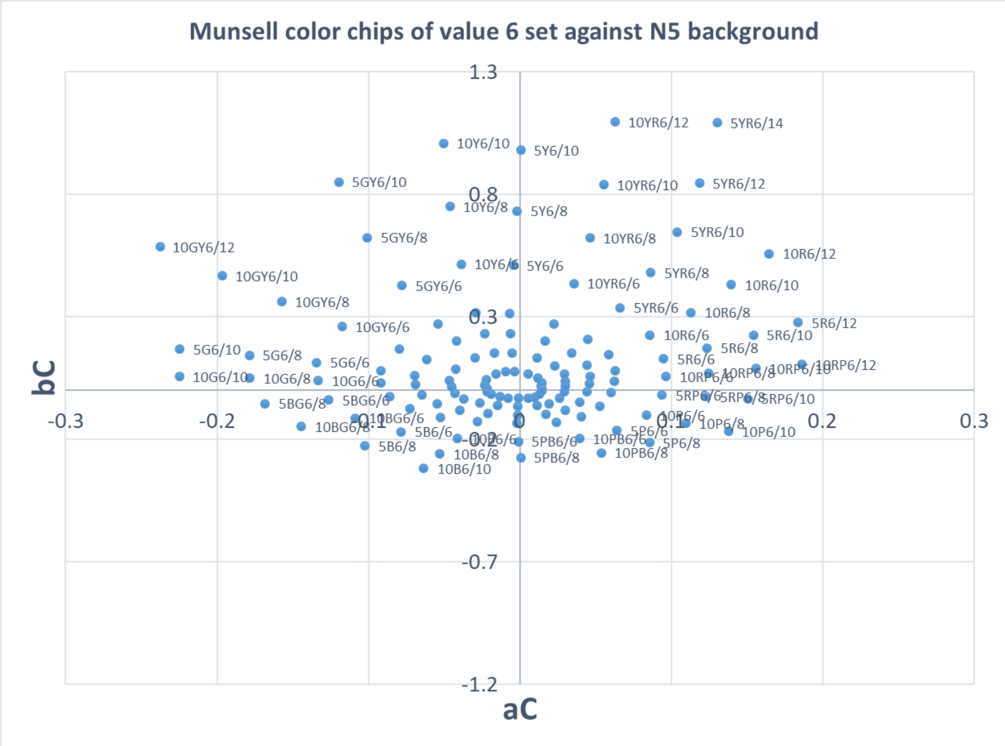

Figure2: Different-hue colour chips of Munsell colour system plotted in aC-bC graph.

Applying this calculation to different-hue colour chips of value 6 set against N5 background in Munsell colour system, we could obtain circular plots of different-hue colour chips as shown in Figure 2, which was a little bit distorted but similar to Munsell colour hue circle. This implied possibility to estimate perceived colour only by obtaining luminous colour contrasts, and also implied that applying spatial filtering to logarithmic X, Y, Z images with appropriately designed filter for contrast extraction could generate perceived colour images. Table 1 showed the contrast extraction filter used in contrast profile method proposed by Nakamura (1993, 2017), which is an approximate of ideal spatial band-pass filter. The authors tried to obtain perceived colour image represented as colour contrast images of LC , aC, and bC from measured luminance and chromaticity images, namely X, Y, Z images, in the real environment.

-9.03E-09	-6.9E-07	-1.4E-05	-8.14E-05	-0.000145	-8.14E-05	-1.4E-05	-6.9E-07	-9.03E-09
-6.9E-07	-4.77E-05	-0.000851	-0.004344	-0.007298	-0.004344	-0.000851	-4.77E-05	-6.9E-07
-1.4E-05	-0.000851	-0.012131	-0.044467	-0.060253	-0.044467	-0.012131	-0.000851	-1.4E-05
-8.14E-05	-0.004344	-0.044467	-0.037362	0.094129	-0.037362	-0.044467	-0.004344	-8.14E-05
-0.000145	-0.007298	-0.060253	0.094129	0.49049	0.094129	-0.060253	-0.007298	-0.000145
-8.14E-05	-0.004344	-0.044467	-0.037362	0.094129	-0.037362	-0.044467	-0.004344	-8.14E-05
-1.4E-05	-0.000851	-0.012131	-0.044467	-0.060253	-0.044467	-0.012131	-0.000851	-1.4E-05
-6.9E-07	-4.77E-05	-0.000851	-0.004344	-0.007298	-0.004344	-0.000851	-4.77E-05	-6.9E-07
-9.03E-09	-6.9E-07	-1.4E-05	-8.14E-05	-0.000145	-8.14E-05	-1.4E-05	-6.9E-07	-9.03E-09

Table 1: Convolution matrix for contrast extraction filter.

EXPERIMENTAL AND RESULTS

First the authors captured X,Y,Z images of a Munsell colour hue circle illuminated by a common fluorescent luminaire shown in Figure 3 (a) and applied the spatial filtering with 5 degrees detection size, resulting 3 colour contrast images of LC, aC and bC, shown in Figure 3 (b). In all contrast images red colour indicated plus values and blue colour indicated minus values as shown in the explanatory bars adhered to them. It is apparent all contrast images showed correct colour appearance of all colour chips.

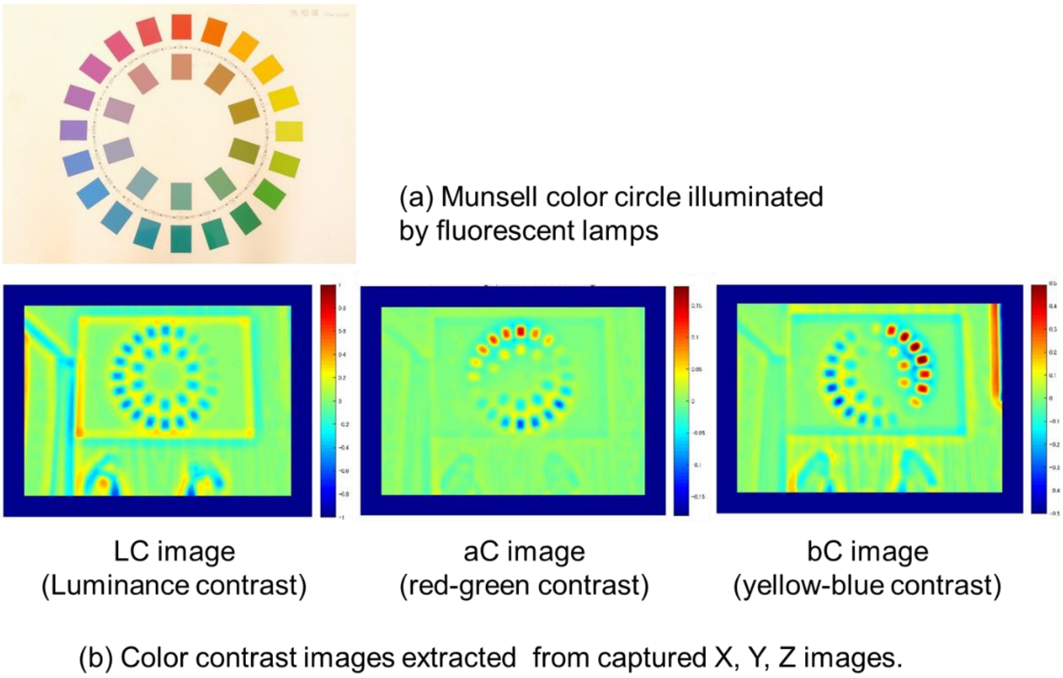

Figure 3: Color contrast images of Munsell colour circle.

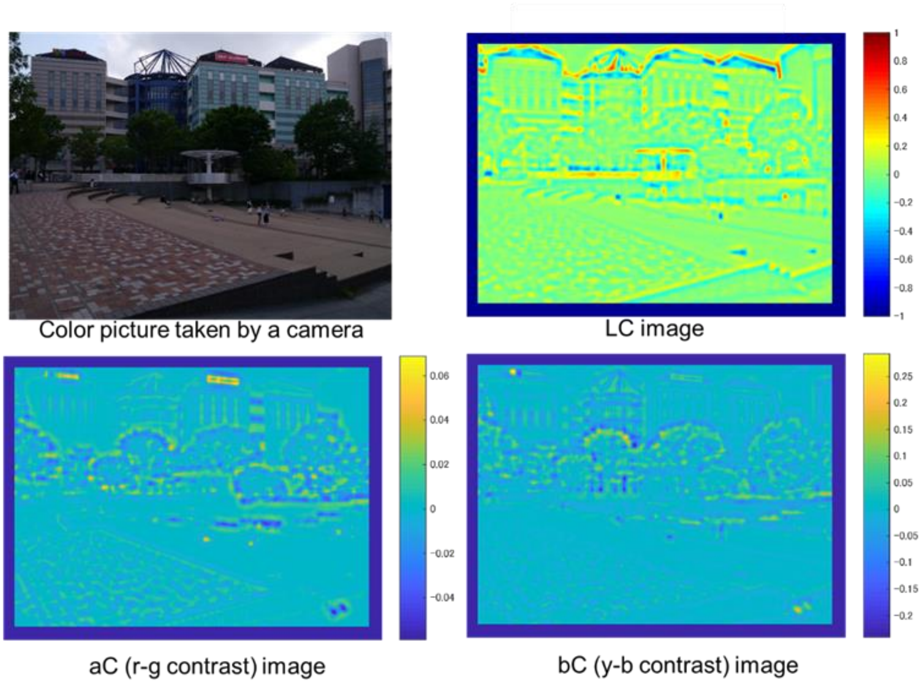

Figure 4: Colour contrast images of real townscape.

Then we capture X,Y,Z images in a real scene of townscape and applied the same procedure to them. Comparing to the colour picture in Figure 5, it is apparent colour appearance of real scene could be represented quantitatively in three contrast images of LC, aC and bC.

DISCUSSION AND CONCLUSION

It is apparent that accurate estimation of colour appearance should take into account of absolute values of luminous colour image. However, difficulty of spatial colour design, brought by difficulty in estimating colour appearance of luminous colours and object colours in real lighted environment, could be more or less resolved by use of colour contrast images extracted from luminous colour image, namely X, Y, Z images. The authors will carry out colour matching experiment next year to establish more accurate colour appearance estimation method.

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Environmental visual literacy: Examining the roles of colour and contrast

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ABSTRACT

Environment-behaviour research indicates that design factors impact the interface between the built environment and human experience. A functionally effective interface supports positive human response and functioning, and may improve orientation, wayfinding and the safe operation of daily activities.

Colour and contrast are two design factors embedded in the built environment via construction materials and cladding, and painted or treated surfaces. It is hypothesized that colour coupled with contrast influences the effectiveness of environmental visual literacy, and may enhance or hinder the functional effectiveness of the interface between human response and the built environment. This paper defines environmental visual literacy and describes a research study that employs colour/contrast supergraphic interventions aimed at enhancing environmental visual literacy.

Depending on the results of this research, it is anticipated that key outcomes will be evidence-based colour/contrast strategies that improve functional environmental visual literacy. This information can be used to ensure the design of the built environment is suitable for all people, especially the aged.

Keywords: *Environmental visual literacy, evidence-based colour strategies, design factors, built environment, colour and human response*

INTRODUCTION

This paper draws together strands of my previous research in the areas of colour theory and application in the built environment; environment-behaviour studies; Gestalt theories of perception and their impact on legibility; and visual literacy (see O'Connor, 2016; O'Connor, 2015; O'Connor, 2011; Rourke & O'Connor, 2009).

It is known that colour and contrast influence the way in which we 'read' and make sense of the world around us, and I hypothesize that specific colour/contrast strategies may enhance environmental visual literacy, thereby contribute to improved orientation, wayfinding and the safe operation of daily activities.

In this research, qualitative research methodologies common to environment-behaviour studies are used to evaluate environmental interventions. These interventions feature colour/contrast supergraphics in two location types: interior spaces (aged care facilities) and exterior spaces (pedestrian crosswalks).

THEORY

This paper draws together theories and research findings from the following: theories of perception including Gestalt principles of perceptual organisation; theories of colour and colour application; Environment-behaviour studies (EBS); Visual literacy research, and refers to a new theory of environmental visual literacy.

In relation to **theories of perception as well as Gestalt principles of perceptual organisation**, colour and especially light-dark contrast are known to play key roles. The retina comprises colour-sensitive cone receptors which number around six million, predominantly located in the fovea area directly in the line of sight. Plus, there are about 120 million rod receptors, located mostly in the peripheral area of the retina. Out-numbering cone receptors by about 20-to-1, rod receptors are sensitive to luminance but not to different colours per se (Goldstein, 1996; Hoffman, 1998; Livingstone, 2002).

Due to the mechanics of human vision plus the operation of saccades and fixational reflex, light-dark contrast plays a critical role in attracting attention and enabling us to differentiate depth and three dimensional form (Kolb, 2003; McPeek, Maljkovik & Nakayama, 1999; Shang & Bishop, 2000).

It is for these reasons, that colour and especially light-dark contrast have been noted as the major drivers for perceiving contours and figure-ground distinctions as per Gestalt principles of perceptual organisation (Koffka, 1935; O'Connor, 2015; Wertheimer, 1938).

In respect to **theories of colour and colour application**, colour is considered to occur across four main categories: Conventional colour (the conceptual notions underlying terms such as 'red' or 'blue); Substance colour in terms of paints, pigments, and dyes; Formula colour (proprietary colours devised by paint companies, car manufacturers, etc); and Spectral Profile colour, which relates to colour as it exists in the form of light waves, computer and television monitors, etc (Green-Armyatge, 2006).

In addition, colour is considered to have three key attributes: hue, tonal value and saturation (Albers, 1963; Gage, 2000; Itten, 1961; Munsell, 1921; Ostwald, 1916).

Hue is invariably defined as the broad colour category and it is the attribute by which we recognise a colour sample using terms such as 'red', 'blue' or 'yellow'. Tonal value is also referred to as 'Value' or 'Tone' and refers to the lightness or darkness of a colour. Saturation, also referred to as 'Chroma', relates to the level of intensity or purity of colour from full intensity through to desaturated, achromatic colour.

Furthermore, Itten identified seven types of contrast: Contrast of hue; Light-dark contrast; Warm-cool contrast; Complementary contrast; Simultaneous contrast; Contrast of saturation; and Contrast of extension (Itten, 1961).

In addition, contrast of hue in conjunction with light-dark contrast and contrast of saturation have been noted as providing the most effective catalysts for differentiation in visual imagery (O'Connor, 2013).

For the purposes of this research, the term **'colour/contrast'** has been used to refer to colours that contrast in hue as well as light-dark variation.

The literature relating to **environment-behaviour studies** comprises theories and research findings that focus on environmental perception and evaluation, and the factors that impact response to building attributes. In general, the key aim of EBS research is to improve the interface between human response and the built environment for people of all ages, and physical and cognitive capacities. EBS research outcomes have informed the development of Universal Design and user-centred design principles, which are now commonly integrated into architectural and industrial design.

Lewin (1967) conceptualised the environment-behaviour interface as follows wherein behaviour (B) is considered to be a function of the interactions between personal factors (P) and the environment (E).

$B = f\,(P, E)$

This conceptual model assumes that behaviour is predicated on varying levels of individual characteristics that may impact environmental perception. It further assumes that the built environment is variable, and EBS research studies tend to focus on a relatively narrow range of individual characteristics and environmental design factors (Lang, 1987; Nasar & Yurdakul, 1990; Ulrich, 1983). Furthermore, we tend to make evaluative judgements about an environment and these judgements may be conscious or unconscious, and occur on a continuous, ongoing basis (Kaplan & Kaplan, 1982).

This paper also draws on the extensive literature relating to **visual literacy**. The term 'visual literacy' was initially defined as "a group of vision-competencies a human being can develop by seeing and at the same time having and integrating other sensory experiences…When developed, they enable visually literate persons to discriminate and interpret the visual actions, objects, symbols, natural and man-made" (Debes, 1969, p.27). In terms of interpreting visual imagery, Ausburn and Ausburn (1978) suggested that visual imagery tends to have a vocabulary, grammar and syntax, and a visually literate person should be able to identify, decode and interpret these in the way they are intended.

My research over the last ten years has led me to develop a new theory of **environmental visual literacy**, herein defined as the way in which users 'read' visual cues embedded in the built environment by way of design factors, and make sense of these in a meaningful way for orientation, wayfinding and the safe operation of daily activities. Environmental visual literacy sits at the interface between human response and the built environment, and relies on functional visual perception, memory and cognitive processing of explicitly noticeable and unambiguous design factors.

Under this theory, strong colour/contrast (that is, 50%+ differential in hue and light-dark contrast) coupled with coloured supergraphics in the built environment, have been identified as design factors that may enhance environmental visual literacy.

EXPERIMENTAL METHODOLOGY

Qualitative research methodologies common in environment-behaviour studies are used in this research to evaluate behaviour in response to environmental interventions. The interventions involve colour/contrast supergraphic strategies aimed at enhancing environmental visual literacy and implemented in two location types: interior spaces (aged care facilities) and exterior spaces (pedestrian crosswalks) with two interventions in each category.

Stage 1: Nominal group consensus technique will be used to evaluate intervention designs (to be disclosed at AIC2018 conference). This technique, which is used to gain consensus in respect to research materials and visual stimuli, involves a group of people considered to have relevant knowledge or experience specific to the aims of a research study who provide valuable feedback and consensus in respect to proposed intervention designs (Waggoner, Carline & Steven, 2016).

Stage 2: In-situ participant observation with unobtrusive research measures and member checking (participant feedback on recorded observations observed sought to ensure accuracy of participants' responses) will be used to assess the impact of interventions on behaviour. This methodology is commonly used in the exploratory phase and in-situ prototype test phase in environment-behaviour studies (Guest, Namey & Mitchell, 2013; DeWalt, Dewalt & Wayland, 1998).

Interventions have been designed for the interior of aged care facilities to create visual markers and 'landmarks', indicating different levels and locations. Resident behaviour will be observed to identify the impact of interventions on orientation and wayfinding among residents. Interventions have also been designed for pedestrian crosswalks in selected locations, and behaviour will be observed to identify whether the intervention impacts pedestrians and drivers. Intervention designs have been inspired by images such as those featured in Figure 1 where colour/contrast is used to identify dining room, different floors, resident rooms.

Figure 1: Colour/contrast strategies to identify dining room, different floors and resident rooms.

For the purposes of this research, colour/contrast design options are currently in development and will be used in Stage 1 of this research. Final colour/contrast designs will be developed in light of feedback garnered at AIC2018 and in conjunction with the existing design of the participating aged care facility.

Exterior interventions have been modelled on dots painted by the Auckland Design Office on Shortland Street, Auckland as a traffic calming measure and to raise awareness about pedestrian safety in the area; pedestrian crosswalks designed by Carlos Cruz-Diez and installed in San Isidro, Lima; and Bankside Broadwalk, an initiative that aims to help pedestrians navigate safely around building sites and roadworks in Lavington Street, Southwark, London, as illustrated in Figure 2.

For the purposes of this research, early concept designs are illustrated in Figure 3. Saturated colour plus strong colour contrast and Resene FX Nightlight white (a highly durable water-based glow-in-the-dark exterior paint) as well as disruptive patterning have been used specifically in these designs to attract attention. The design process has been informed by information about the mechanics of human vision and the operation of saccades and fixational reflex. Final colour/contrast designs will be developed in light of feedback garnered at AIC2018 and in conjunction with the participating local council.

Figure 2: Colour/contrast supergraphic interventions in New Zealand, Lima and England.

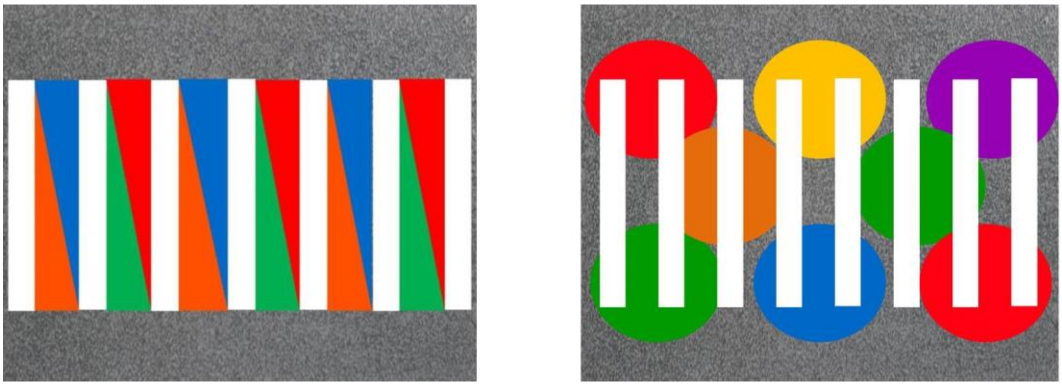

Figure 3: Early concept designs for crosswalk interventions.

RESULTS AND DISCUSSION

Results from Stage 1 (nominal group consensus feedback to be conducted AIC2018) will be used to modify further colour/contrast supergraphic interventions. These modified interventions will be used in Stage 2 and results from this research will be published in due course.

CONCLUSION

This paper proposes a new theory of environmental visual literacy whereby the design factors colour and contrast work in tandem and contribute to the perception and evaluation of the built environment. It is hypothesized that colour/contrast strategies (50%+ contrast) enhances environmental visual literacy, thereby contributing to improved orientation, wayfinding and the safe operation of daily activities.

Qualitative research methodologies common to environment-behaviour studies are used to evaluate behaviour in respect to environmental interventions. These interventions feature colour/contrast supergraphics in two location types: interior spaces (aged care facilities) and exterior spaces (pedestrian crosswalks). Results will indicate optimal levels of colour/contrast for effective environmental visual literacy.

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Environmental colour mapping and a case study for Istanbul, Beşiktaş

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ABSTRACT

A conscious and systematic façade colour design in a settlement depends on considering the factors and data about natural-artificial environment and visual perception for all scales of a settlement. In other words, a successful façade colour design in settlement scale is based on the urban colour plans. In the preparation process of urban colour plans, the basic study is analyzation of the environmental colours. These analyses which are called environmental colour mapping, constitute a reference for the colour planning and colour design of facades and other urban elements. Also an archive which has all natural and artificial colours of the settlement, is developed by environmental colour mapping. In this study basic steps of an approach about the facade colour design in settlements are given and a case study on the environmental colour mapping which is one of these steps is illustrated in the natural and artificial environment of Yıldız Technical University, Yıldız Campus.

Keywords: *Colour mapping, Environmental colour analyses, Facade colour, Colour planning, Colour master plan*

INTRODUCTION

Natural and artificial environment colours, affecting greatly the appearance of the street, the square or the city region that they are in, have great importance in terms of improving the appearance and achieving a visual identity etc. for these elements. Thus, maintaining a systematic and conscious colour design in a settlement depends on considering it at all scales of the settlement such as street, square, city region and the whole city area analysing the data and the factors related to the natural and artificial environment deeply for each scale and preparing the urban colour plans based on the findings obtained.

In this context, an approach has been developed in the PhD Thesis, "An Approach for the Facade Colour Design in Settlements" including the four basic urban colour planning stages and guide the process of the creation of Urban Master Colour Plans. These stages are as follows.

- Defining the buildings and the region (district, street, square etc.) of the settlement that have colour designing priority
- Performing the environmental colour mapping of the urban region and the buildings
- Defining and evaluating the properties specifications of the urban region and the buildings that affect the colour perception
- Making colour suggestions for the urban region and the buildings

As seen in the stages of the approach, in the preparation process of urban colour plans, one of the basic study is analyzation of the environmental colours. These analyses which are called environmental colour mapping, constitute a reference for the colour planning, colour design of facades and other urban elements. In this study environmental colour mapping is illustrated in the natural and artificial environment of Yıldız Technical University (YTU), Yıldız Campus situated in Beşiktaş, İstanbul.

ENVIRONMENTAL COLOUR MAPPING

Environmental colour mapping studies can be defined as analysing all the colours of a settlement's natural and artificial environment and defining them in terms of colour palettes in order to make a complete archive. Colour mapping have been performed in some countries for many years and the colour planning of the settlements have been carried out according to the results obtained from the analyses. In this way, sustaining the colour identity of the settlements is achieved. This concept enables us to preserve the unique colours of the buildings especially in the areas where the majority is historical buildings and to colour the new buildings in compliance with the current state.

Environmental colour mapping, also called in the literature as colour analyses or making colour diagram, must be performed separately for the settlement's

- natural environment (the sky, green elements/plantation, soil, water elements etc.) and
- artificial environment (building facades and roofs, floor coverings, urban furniture etc.)

During these analyses, the colours of the fixed and temporary elements related to the natural and artificial environment such as flora, the buildings, urban furniture, mass transportation vehicles, advertisement boards, coloured lightings etc. should be determined and their contribution to that settlement's colour identity should be analysed. In compliance with the data obtained from the environmental colour mapping, defining the colours of the fixed and temporary elements in a way that no harm on the colour identity and colour perception of the settlement will prevent the colour pollution.

To analyse the natural and artificial environment colours, contributes to the considered settlement in terms of

- creating its colour memory in regard to its visual environment
- protecting its visual/colour/architectural identity
- being a reference source for the restoration/renovation studies especially in the areas where the majority is historical buildings
- providing data for colour designs of all of the elements like the building facades, urban furniture, advertisement boards etc. and

- acting as a guide for the local authorities, architectures, colour designers and building occupants in terms of the principles of colour designing

In this regard, a case study for environmental colour mapping including the natural and artificial environment elements is performed in order to protect the colour memory and architectural identity of the Yildiz Technical University, Yildiz Campus.

ENVIRONMENTAL COLOUR MAPPING FOR YTU YILDIZ CAMPUS

This case study intended for the second stage "Environmental Colour Mapping" of "An Approach for the Facade Colour Design in Settlements" process is a limited study considering the artificial and natural environment elements present in Yildiz Technical University, Yildiz Campus. The fact that the majority of the artificial environment elements in the campus consist of the historical buildings that belong to Yildiz Palace settlement in Ottoman Empire Period and they are located in a densely green area increase the importance of the effect of the building facade colour on the visual environment.

Academic education in YTU Yildiz Campus first started in 1911 with The Conductors (Technicians) School of Higher Education. Today, there are several buildings such as Faculty of Architecture, Faculty of Mechanical Engineering, Vocational School of National Palaces and Historical Buildings, Administrative Building, Rectorate Departments and Institutes located on an area of approximately 80.000 m2. Also, in the campus there are auditorium, library, bank, rectorate building, kindergarten, and cafeteria. There are also many evergreen agelong trees and green areas in the settlement.

For determining the colours of the natural and artificial environment elements of the YTU Yildiz Campus, colour mapping method that is widely referred in the literature and also used by the French designer and colour specialist Jean-Philippe Lenclos is adapted. The stages of the Environmental Colour Mapping studies are;

- analysing and defining the natural and artificial environment elements and their colour specifications on site and documenting them by means of coloured sketching, taking pictures etc.
- collecting colour samples from the documented natural and artificial environment elements, registering these samples and grouping them
- classifying the grouped samples according to a certain colour order system via colour matching or colour measurement methods
- preparing the samples such as diagram/colour palette/map etc.
  for the defined environmental colours

Within the limited scope of this study, among many buildings in order to determine the ones for which colour analysis will be performed a walking route that is commonly used by the pedestrians in the campus is defined. This route starts with the South entrance of the campus, follows the roads and the squares and ends at the Rectorate Building. The natural environment elements in the campus such as soil, water, flower etc. are not taken into consideration due to the fact that the area they occupy is limited when compared to the green areas and that they are not in the field of view.

The stages of the environmental colour mapping are applied separately for the natural and artificial environment of the YTU, Yildiz Campus. In the scope of the Natural Environment Colour Mapping study carried out in Yildiz Campus, the green areas on the walking route, item of the natural environment elements, were examined in spring time. They were documented on site via taking their pictures, samples were collected and numbered. The Munsell Colour System symbols of the numbered samples were determined in YTU Faculty of Architecture, Building Physics Laboratory via colour matching method.

Figure 1: YTU Yildiz Campus green area examples and determining the leaf colours.

Table 1: Munsell Colour System symbols of natural environment elements.

No	Plant Name	Hue	Value	Chroma	No	Plant Name	Hue	Value	Chroma
N1	Magnolia	35	3	2	**N5**	Viburnum Tinus	35	4	4
N2	Aesculus Hippocastanum	35	4	5	**N6**	Pyracantha Coccinea	35	3	3
N3	Ampelopsis Veitchii	37,5	4	4	**N7**	Medicago sativa	35	5	8
N4	Prunus Laurocerasus	35	5	5	**N8**	Pinus	35	4	4

Average hue, value and chroma degrees of leaf colours related to the natural environment are calculated by the arithmetic mean method and the environmental plant colour is determined as 35-4/5.

In the scope of the artificial environment colour mapping carried out in Yildiz Campus, the buildings, urban furniture, floor and wall coverings on the walking route are documented and numbered by taking their pictures. The Munsell Colour System symbols of the considered elements are determined on site by colour matching method under clear sky condition.

Figure 2: Artificial environment elements examples of YTU Yildiz Campus and determining the colours of artificial environment elements.

Table 2: Munsell Colour System symbols of artificial environment elements.

No	Building name	Hue	Value	Chroma	No	Building name	Hue	Value	Chroma
B1	Faculty of Economics and Administrative Sciences	10	6	8	**B13**	Rectorate Building	20	8,5	3
B4	Cafeteria	32,5	8	5	**WC**	Wall Covering	10	5	7
B7	Faculty of Mechanical Engineering	N	9	0	**FC**	Floor Covering	10	5	5
B10	Faculty of Architecture	10	7	6,5	**UF**	Urban Furniture	15	7,5	5,5

*B7 (Mechanical Engineering Faculty) Building facade is ivy-mantled (37,5-4/4).

EVALUATION AND CONCLUSION

During the analyses performed on the artificial environment elements of Yildiz Campus; it is determined that the colours of the buildings such as restaurants, cafes, educational buildings, cultural buildings etc. are generally yellowish red at 10 colour hues with different values and chroma degrees. The colour of the other minority buildings that have the aforementioned functions is achromatic (grey). It is also determined that the colours of the buildings such as cafeteria, supporting services, etc. generally consist of light and low-mid chroma, yellow-green and green-blue colours having 35 or 55 colour hues. The rectorate building different than the other buildings has light and low chroma, 20 hues, reddish yellow colour. Also, the wall and the floor coverings located in the Campus have medium dark and mid-high chroma, 10 hues, yellowish red colour.

When the natural and artificial environment elements on the determined route are taken into account as a whole in the study of YTU Yildiz Campus, it is seen that for artificial environment elements the yellowish red at the 10 hues and for natural environment elements the yellow green at the 35 hues are the colours that cover most of the area in the field of view. It means that warm coloured building façade, urban furniture and floor-wall coverings are used in the cool coloured green areas. When the current natural and artificial environment elements are considered in Yildiz Campus, it can be derived that colour arrangement close to hue contrast exists in the campus.

The data that are obtained from the environmental colour mapping case study performed in order to determine the effects of the building facade colours on the visual environment and to protect the architectural identity and prepare the colour memory of the campus can be used in future in the colour designing works that will be performed in the campus. In the same way, the environmental colour mapping studies that will be carried out at all sequential scales of a city such as street, district, city region and the whole city will be a guide in the colour planning studies that will be carried out at all scales.

In other words, environmental colour mapping that will be carried out in compliance with the specifications and requirements of each settlement will contribute to the Urban Master Colour Plan that will be prepared at the whole city scale. In conclusion, the importance and contribution of the colour mapping in terms of urban colour planning can not be discarded and the local authorities should handle the subject with high consideration. Accordingly, local authorities should collaborate with urban planners, architectures and colour designers and more studies should be carried out especially in the regions where historical buildings and local architecture samples constitute the majority.

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colour & human comfort

The Green in Architectural Rehabilitation

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ABSTRACT

The aim of the article is to alert to the fact that architecture must comprehend Nature and bring it back again into the daily life of Man, increasing his physical and psychological comfort. The "Green" in Architectural Rehabilitation can have several meanings and approximations. In this article we address "Green" as Colour and Attitude. This paper has been developed through deepening the hypothesis of the colour green in living coatings. These allow creating solutions that avoid the formalisms of architectural language, being of special relevance their application in the Architectural Rehabilitation of the Heritage. Examples of green roofs and green façades are presented. As a case study we have selected the Rehabilitation of the Portalegre Cathedral.

Keywords: *Architectural Rehabilitation, Green walls, Green roofs, Algae, Biological concrete*

INTRODUCTION

Green is dominant in nature, as it is the colour that is best perceived and visible to the human eye.

This fact is due not only to species' evolutionary factors, but also to the importance of photosynthesis in our planet. This relationship inherent to the natural world, as the exposure to nature, benefits our health. Hence the importance of designing green environments, whether is through urban planning, green architecture or through architectural rehabilitation with living coatings. It's central to bring nature to the everyday of the urban man, who is increasingly removed from it, thus enhancing his physical and psychological comfort.

In the shades of green, the Chartreuse Green is the most visible to man. As it's compound by 50% green and 50% yellow, it appears in the middle of the spectrum of colours visible by the human eye.

Some of the pigments used to make the green colour have side effects, which can lead to poisoning. For example, the emerald green, appreciated by painters like Cézanne, Monet and Van

Gogh, degraded itself spontaneously, causing the paintings to emit vapour of high toxicity based on arsenic.

Nowadays, it is questioned whether the diseases that those painters contracted, would not be provoked by the inhalation of those toxic vapors.

Another green shade, which today is proved to have had nefarious effects, was Scheele's Green created in 1775 and used in paintings of interior coatings, tapestries and furniture.

THEORY

The green roofs have been part of the architect's imagination since the Hanging Gardens of Babylon.

Living coatings allow creating solutions that avoid the formalisms of architectural language, being of special relevance their application in the Architectural Rehabilitation of the Heritage (Figure 1).

Figure 1: Portalegre Cathedral: Terrace View to the Green Roof of the Permanent Exhibition Room in the southwest courtyard. Rehabilitation made by RBD.APP, 2016.

Figure 2: Portalegre Cathedral: South courtyard before Rehabilitation, 2015.

Whether on the roof, on the façade, or on the floor, living coatings are proposals for quality finishing.

Their aesthetic aspect is fundamental, making it possible to obtain completely different solutions by the option of the colour changing, according to the seasons of the year.

Since the antiquity that creepers have been traditionally used to coat walls, composing green façades (Figure 2).

Plants may be selected depending on the colour of the flowers, leaves, or both. There might be green areas of the coatings, while others may appear in red, brown or in various colours through the blossoming of the flowers (Figure 3). Even in green areas it is possible to choose different shades and gradations of colour.

Figure 3: Portalegre Cathedral: South courtyard. Rehabilitation made by RBD.APP. Landscape: ARPAS, 2016.

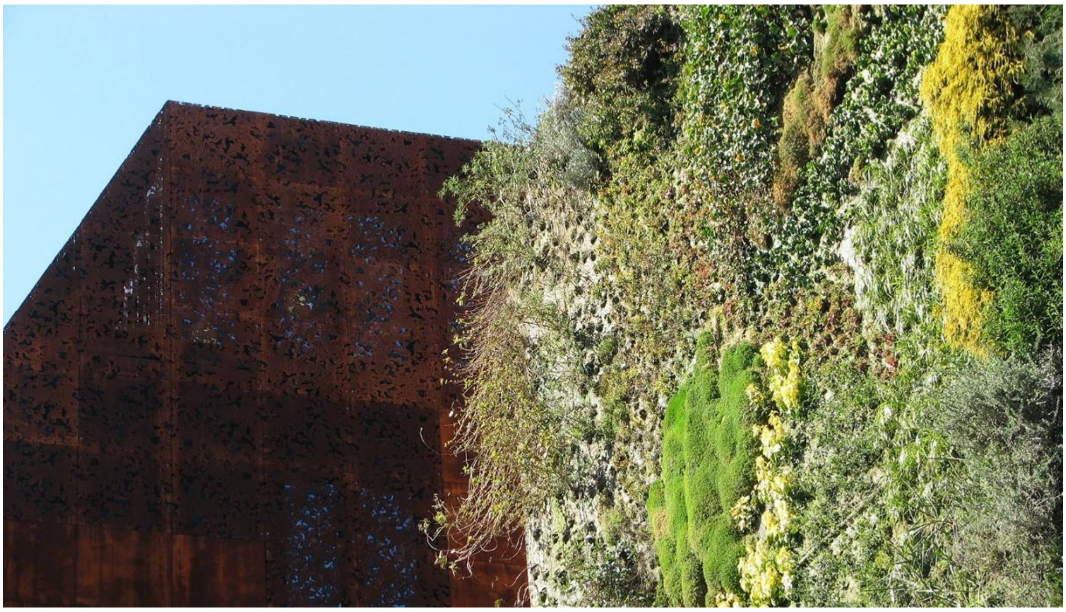

Figure 4: *Caixa Forum* and green façade in the building of the *Caixa Forum* Square, Madrid, 2007. *Herzog & de Meuron* and Patrick Blanc. Photography: Ana Paula Pinheiro, February 2009.

On the opposite of the solutions developed in the Rehabilitation of the Portalegre Cathedral - where it was used the traditional system of coating with creepers -, although supported by loose steel wall cables, the green façade built in the Caixa Forum Square in Madrid, authorship of Herzog & Meuron and Patrick Blanc, is based on a new technic of vertical culture without a ground (Figure 4).

This new solution, patented by Patrick Blank (Request of the Patent 08.08.88; in force since 10.07.92), ensures the vegetation of building surfaces, regardless of height, without substrate weight problems. This vertical garden has about 20.000 plants belonging to 3000 different species.

There are several competing brands that show variants to this system developed by Patrick Blank.

Another type of green façade was created in 2013 in Hamburg, Germany with the use of microalgae, produced in the skin of the building.

The microalgae grant the green colour, without being necessary another finishing.

With a concept of holistic energy, they generate electric energy and produce heat. It can be stated that it's a triply green building: colour, energy and heat (green energy).

This principle of conception can be used in architectural rehabilitation, whether it is on building skins, or in light-breakers, or in building's expansions.

In Spain, at the *Universitat Politècnica de Catalunya* in Barcelona a new concept of vertical garden was developed that allows the choice in a colouring area, without needing support structures.

It was created a concrete that performs as a natural biological support for lichens, mosses and other microorganisms that confer various green shades.

The biological concrete, besides having aesthetic characteristics, may function as a thermic isolator and regulator. Thanks to its biological coating, it absorbs and reduces de CO2 in the atmosphere.

NEGATIVE FACTORS

There are negative aspects in the use of live façades in Architectural Rehabilitation: the plants may catch diseases, may die or may need to be pruned.

It is necessary to wisely choose what kind of plants to use in order to avoid this type of situations and to minimize its respective maintenance.

The green roofs aren´t always the best option in Architectural Rehabilitation as its weight is superior to the traditional roofs. Besides that, those are easier built in flat roofs or slopes inferior than 35º.

GREEN AS ATTITUDE

It is critical to address the paradigm shift and reflect on climate change and how it is interfering with all fields of architectural creation.

The "Green" as an attitude should be developed from the sustainable rehabilitation point of view - construction, implementation, maintenance, deconstruction - covering its whole life cycle, in order to minimize environmental impact, with applications to the architectural design process.

The architectural rehabilitation must be performed so that buildings have a high-energy performance and require almost zero, or very small amounts of energy produced by renewable sources, Nearly Zero Energy Building, NZEB.

Green walls and green roofs increase the thermal and acoustic insulation of buildings and allow natural shading. In addition, they improve the quality of the air, purifying it, increasing the comfort of the users.

Combining ventilation and air purifying plants, the green façade increases the quality of the air, while associating scents of nature.

It is possible to optimize the consumption of water, whereas carefully choosing the ornamental vegetation and optimizing the association of cacti and grasses.

The plants can still be used to treat grey water and can contribute to the innovation of water management and ventilation systems.

CONCLUSION

The green is essential in the human life. Architecture must comprehend Nature and bring it back again to the daily life of Man, increasing his physical and psychological comfort.

Complementarily it is necessary to think Architectural Rehabilitation in order to achieve the NZEB - Nearly Zero Energy Building.

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The main elements of the colour design process of a new neighbourhood – The case Koivusaari in Helsinki

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ABSTRACT

The case Koivusaari is an urban design project, focusing on the detailed plan and design guidelines. This doctoral research gives practice-led information about the architectural colour design, particularly on the formulation of the detailed plan and design guidelines. This paper describes the colour design process of Koivusaari and compares it with other large-scale architectural colour design projects. The study utilises Research by Design as a method: colour designing of the Koivusaari case and analysing the design process and available data as a researcher.

This study has identified eight steps in the colour design process in the Koivusaari case. The starting of the colour design process is quite similar to other large-scale colour design projects. However, the target of the Koivusaari case is not to design the specific colours of the facades as is done in large-scale projects. Instead, its aim is to define the atmosphere of architectural colours for the new neighbourhood.

Keywords: *Colour design, Urban design, Colour research, Detailed plan, Atmosphere*

INTRODUCTION

This paper addresses the steps of a colour design process, which have arisen from large-scale architectural colour design research. The paper will discuss the preliminary findings of my on-going doctoral research titled: *The Colour Design of Architecture to a New Neighbourhood: The Case Koivusaari*. The PhD project is practice-led research about the colour design of new housing districts in Helsinki, Finland. Koivusaari will be a new built island in a sensitive archipelago of the Baltic Sea. It will be a home for 5000 inhabitants and a workplace for 4000 people.

The main question of this paper is practical: How to design the colours of a new neighbourhood and what are the steps of the design process? The second question is: How to design the atmosphere of the new neighbourhood with architectural colours? With this second question, I connect my research to the conversation about the atmosphere of architecture and verify the role of colour in *making the atmosphere (Böhme 1993/2017).*

THEORY

During this research project, I acted as the colour designer on the Koivusaari-Lehtisaari Team, Detailed Planning, Land uses and City Structure, Urban Environment, City of Helsinki in 2016-2017. The project started with analysing the site and making the first sketch and continued with the colour workshop with other architects, the main colour designing, and the colour idea formulation for the detailed plan and design guidelines. The detailed plan defines the qualitative features of the new neighbourhood, such as building height, building materials and colours. The design guidelines direct the main principles of architectural design.

The research method is research by design, which gives practical inside information about the colour design process. First, I worked as a colour design consultant for the city of Helsinki. Then I analysed the material as a researcher. The research data is diverse: sketches, photographs, notes, voice-recorded meetings, NCS measurements, SkechUp model and cardboard 3D model. During the design process, I wrote notes and reflections about the working process and about how the process resonates with the literature and other parts of my doctoral research. In addition to addressing the colour design process in Koivusaari, this research reviews other large-scale colour design processes: Smedal's colour designing for Longyearbyen, Norway, and Lancaster's research on colour strategies in England. This research aims to provide understanding of the main elements of the colour design process of a new neighbourhood by comparing the processes of Koivusaari with those of Smedal and Lancaster. In addition, Lenclos's methods of analysis of architectural colour have been considered in this research.

THE MAIN ELEMENTS OF THE COLOUR DESIGN PROCESS OF A NEW NEIGHBOURHOOD

This study has identified eight steps in the colour design process of the case Koivusaari, each of which has a specific aim and purpose.

Figure 1: The view to Koivusaari from the south, 16th February 2016. Koivusaari is situated in the middle. On its left is Espoo and on its right Helsinki. The elements of the landscape are the sea, the sky and a band of the islands. The colours of the Baltic Sea are grey, green, blue. In the winter, the sea is frozen. "Grey" weather is common.

1) *Introduction:* The first steps of the new colour design project include familiarising with the facts, the earlier report such as the maps, the planning and the 3D model of area[1]. This 3D model was made by Koivusaari-Lehtisaari Team few months before when I started. The colours of the buildings were added by the planning department to avoid a white model. The experience-based information on site is equally as important as the previous step in the induction. Koivusaari is an

[1] https://www.youtube.com/watch?v=lgHtIlGqAO4

island, so it is necessary to walk on the island and study it across. *(Fig. 1)* A designer needs to have intuitive understanding about the atmosphere of the site in different seasons, weathers and illuminations. After the first step, the designer has confidence, sense and understanding to formulate the analysis. What kind of analysis is needed in this special designing case?

Figure 2: The cityscape with SkechUp-model with the previous picture. On the left side of buildings will be four white skyscrapers at Keilaniemi in Espoo.

2) *Analysis*: In the Koivusaari case, I made four types of analysis: First, I needed more information about the coming urban design of Espoo, because Koivusaari was the border between the two towns, Helsinki and Espoo. Second, I needed more understanding about the cityscape in the winter and summertime from four viewpoints. Third, I merged a perspective with a 3D model for panorama pictures in Photoshop. The goal was to understand how the building process will change the landscape and cityscape. *(Fig. 2).* Fourth, I made an analysis of the colours and the materials of the architecture of Lauttasaari, which is the adjoining neighbourhood in Helsinki. I took photographs and made colour measurements with NCS from the plastered facades to have understanding about thee colour scale of the earlier architecture. After four different types of analyses, I wrote the conclusion and the main starting points to the colour designing.

3) *Sketches and colour concept:* The colour concept and the first sketches arise from the deep analysis of the site. The colour concept illustrates a new vision of the colour scale of Koivusaari with a photo-based collage. It relays more an impression than the final colour scale. One purpose of the colour design of Koivusaari is to create the identity of the new neighbourhood with colours and connect the new neighbourhood to the landscape and the cityscape. On the north side of Koivusaari, the colours come from the colour scale of the reeds at the shoreline after the winter: ochre, yellow, grey, brown. The colours of Koivusaaren poukama, Koivusaari bay, come from typical old fishing harbour buildings, with Falun red-type red and grey. In the other parts of Koivusaari, the colours come from rocks, lichens and skerries on the Baltic Sea. There will be ten smaller areas, in which the colour scale varies and helps with orientation.

4) *Perspective of colourscape:* The colour design of a new neighbourhood is connected with the political decision making. The sketch of the detailed plan of the neighbourhood has to be accepted in the City Planning Committee. The perspective picture was needed to show the main idea and the colours of the area and how the buildings change the cityscape and the landscape.

Figure 3: The right side with yellow-red-brown-scale has remained the same in the last version. The left side with green buildings has developed in the next steps of planning. The detailed plan is going to City Board in 2019, so unfortunately the pictures of the next four steps are not public yet.

5) *Colour Workshop:* The second part of the colour design continued after the permission of The City Planning Committee. The goal was to do the main colour design and detailed plan and design guidelines for architects. We started with a colour workshop. First, I give an introduction of the colours of the nine other neighbourhoods in the capital area of Helsinki. The atmosphere of the discussion was very open. Before the event, I had asked the Koivusaari urban design architects for pictures about ideal and non-ideal examples from other neighbourhoods. We also discussed critically the earlier steps of the Koivusaari project, the target of the detailed plan, the vision of the new island and identity of the smaller parts. The colour workshop differed from an ordinary meeting, because I analysed and coded the recording. The analysis gave information and a direction to the colour design process, the design methods and shared target how to formulate architectural colours to the detailed plan.

6) *Additional analysis:* The urban planners still worked with the west side of the island when I did the main analysis. Before starting the main colour design, I needed additional analysis. I merged a view from the west to a picture in Photoshop.

7) *Colour design of the neighbourhood and the blocks:* This step turned the focus of the designing from the cityscape to inside the island. The starting point was the experience of a pedestrian and a resident. What kind of views and continued spaces does the new architecture offer? What is the influence of the architecture and the colours on the experience? I designed the colour scale for the island's ten blocks to update the SketchUp -model. The colours of six blocks will be defined in the design guidelines. At the same time, I had the watercolours, the colour pencils, the specific NCS colour examples, and the photos from nature and SketchUp model on the screen on my desk. How to twist and turn the idea of the colour scale of nature, to the colour scales of buildings? What kind of green or red are not too dark or intense or light? How to build a harmonius variety of colours? The NCS colour examples show the demarcation of the colour scale.

8) *Detailed plan and design guidelines:* The Koivusaari case was the second new neighbourhood where new design guidelines, The Block Cards", were used. Their idea is that the architect will have two A4 pages, one about the whole area and one about the special block from his/her site. The openness of the future is the significant challenge of the colour design guidelines: How can a colour designer even make architectural colour designs 10 to 20 years into future? I used several types of medium to formulate the colour information for new architecture. The design guidelines were textual description, a picture from nature, a perspective from SketchUp-model, a colour scale in watercolours, a scale of NCS nominal colours. The target is to give a direction of identity to the island, a direction to the cityscape and at least a nominal colour scale with the colour examples with NCS. In this scale and purpose, the specific nuance of colour is not so important.

RESULTS AND DISCUSSION

This practice-led research shows that the beginning of the colour design process are similar in the large-scale and in the design guidelines. First, *Introduction (Pyykkö)* is needed. Smedal calls it *Registration*, and Lancaster *A survey of the site and surroundings*. Second, Smedal, Lancaster and Lenclos argue for systematic and deep *Analysis* about the site, the architecture and the surroundings with different methods, around the clock and during different seasons, and taking into consideration the influence of the new buildings on the landscape. The third step involves *Sketches* or formulating the objective (Smedal) or *Sketches and Colour concepts* (Pyykkö). The fourth step is the main *colour designing*; *Overall colour plan* (Smedal), *The colour strategy plan*

(Lancaster) and *Colour designing of the neighbourhood and the blocks* (Pyykkö). The result of the colour design process is *Colourisation house by house* (Smedal), *The colour strategy plan* (Lancaster) or *Detailed plan and design guidelines* of Koivusaari.

The colour designing of a Koivusaari differs from the colour designing of these other examples in the later phases. In the Koivusaari case, *Perspective of colourscape, Colour workshop, and Additional analysis* were needed before the main colour plan. On the other hand, Smedal and Lancaster focused more on how the colour plan is presented to the audience and how the colour plan will be followed in the future. The colour design of the Koivusaari case is not "colouring" of buildings. It is crucial to understand the site, to create the specific atmosphere and identity, and design the colour scale for the architecture of the new neighbourhood. This resonates with Böhme's idea of *making the atmosphere* to a scene, architecture or garden. Colour is one important tool for influencing the atmosphere. One purpose of the Koivusaari project is to create an identity for the new neighbourhood with colours and connect the area with the cityscape. Architectural colour is a strong medium for connecting the built environment with the landscape and for designing the atmosphere of a neighbourhood.

CONCLUSION

The beginning of the colour design process in Koivusaari was quite similar to Smedal's and Lancaster processes, as they all emphasise the importance of the analysis of the site and existing architecture. In addition, they consider the effect of seasons and weather. However, the target in the Koivusaari project is not to create the specific colours to the facades. Instead, the target is to create the identity of the new neighbourhood with colours and connect Koivusaari with the surrounding landscape and cityscape in all seasons. In the detailed plan and design guidelines, it is important to have both harmony and variety and to keep the identity of the new neighbourhood clear. The colour design process of Koivusaari resonates with Böhme's concept of *making the atmosphere* but extends it to making the atmosphere with colour in a new neighbourhood.

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Conceptualization of Colour and Light in Interior Spaces: Gelre Hospital in Zutphen and Underground Parking in Katwijk-aan-Zee

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ABSTRACT
The way plants, animals and individuals convey and collect intended meaning and information to their surrounding through colour and light is the source of inspiration for this paper. The author, as the interior architect of both case studies, details the process of conceptualization of colour and light schemes in interior spaces. The projects – Gelre Zutphen Hospital and Katwijk Parking Garage – differ in size, use, and complexity, however, both design plans have a holistic approach that focus on functionality and user's experience. The cohesive light and colour schemes are founded on three main aspects: general atmosphere, communication, and orientation.

Keywords: *Colour, Light, Communication, Orientation, Conceptualization*

INTRODUCTION
Nature exchanges information with individuals in ways that appeal to all senses. Colour and light are some of the channels that nature uses to communicate and orientate, just like temperature, shapes and textures, movement and speed, smell, etc. Therefore, it is important to look at nature when creating humanised and comfortable spaces, not by replicating structural forms found in it, but, as Salingaros (2016: 94) mentions, by "finding the answers in the cognitive processes, in perception, and in neurophysiology". The thoughtful manipulation of space through colour and light is more efficient when it addresses the physically, mentally, and spiritually oriented senses (Meerwein et al., 2007), such as the senses of self-awareness, well-being, comfort, spatial orientation, scale, intuition, empathy, among others. It emphasizes the relationships between the individuals and their environment, making the architectural space communicate through non-verbal elements of the design, as optic signals, sensory perceptions, and visual messages.

COMMUNICATION

> *Until the onset of Modernism in the visual arts and architecture in the second decade of the twentieth century, the relation between colour and architecture – seen through the relationship between artists and architects – was complementary.* Pimlott (2009:78)

The use of colour in architecture has come a long way since and is no longer used as a pure cosmetic element of architecture, an expression of the architect's artistic skills or of an invited artist collaboration. Pimlott (2009) mentions two strategies for the use of colour in architecture: disruptive and dissolvent. Where colour can clash with the architectural space (e.g. Antoni Malinowski's intervention on Haworth Tompkins' Donmar Warehouse), or merge with it (e.g. Luis Barragan's *Cuadra San Cristóbal*). In this essay it is proposed a third one – the communicative strategy, where colour and light are used in a way that enhances the architectural qualities and guides users to a better understanding of the space. The communicative strategy incorporates both disruption and integration, by using colour and light to call the user's attention away from the architectural space and redirecting it to specific information. As Merleau-Ponty (1999:328) refers, "space is not the environment (real or logical) in which things are displayed, but the medium by which the position of things becomes possible".

In order to exemplify this communicative strategy, it was chosen two very different projects designed under these concepts – the Gelre Zutphen Hospital (GZH) and the Katwijk Parking Garage (KPG). The two projects were developed by the international firm Royal HaskoningDHV, where the author was leading the interior design team. The distinct characteristics of each project are described in table 1.

	GELRE HOSPITAL ZUTPHEN	**KATWIJK PARKING GARAGE**
Location	Zutphen, The Netherlands	Katwijk-aan-Zee, The Netherlands
Year	2006-2010	2010-2015
Function	Health Care	Transports / Infrastructure
Plot Size	26.500 sqm	15.000 sqm
No. Floors	5 (B, GF, 1st, 2nd, 3rd)	2 (B, GF)
Geometry		
Client	Stichting Gelre Ziekenhuisen (Gelre Hospitals Foundation)	Municipality of Katwijk
Intervention: Functional Areas	H1. Rooms, Corridor, Waiting Areas; H2. Entrance, Waiting Areas, Restaurant; H3. Rooms, Corridors, Waiting Areas	Parking Area, Circulation, Main and Secondary Entrances
Intervention: Space Components	Floors, Walls, Prints, Ceilings/Lighting (in common areas), custom-made furniture and fabrics	Floors, Walls, Prints, Ceilings, and Lighting
Colour & Light Attributes	Psycho-Physiological Effects	Anthropological Aspects

Table 1: Projects' Characteristics Differential (Source: Author, 2018).

The Gelre Zutphen hospital, one of two of the Gelre Foundation, is composed by two complementary building elements, the semi-private (H1) and the private (H3), that are connected by a third, the public element (H2). Privacy levels, here, refer to the accessibility and levels of clearance of the hospital users: Private – hospital staff (doctors, nurses, administration, maintenance and cleaning personnel) and inpatients; Semi-Private – hospital staff, inpatients, outpatients, patient's visitors / accompanying people; and, Public – accessed to all users.

The Katwijk Parking Garage presents a much simpler spatial organisation. Located under the dunes, it is composed by one long continuous element that incorporates the vertical pedestrian's accesses and two car entrances on its extremes.

CONCEPTUALIZATION

At the GZH, the colour and light plan emphasises the distinction of internal areas and functions, with two main atmospheres (Figure 1). H1 and H2 have a warm, welcoming feel, and focus on the patient, reflecting the building exterior ambiance created by its wood façades. The H3 has a colder, technical feel, and focus on the treatment and technology, also reflecting its exterior façade of glass and metal. Two mood boards, which depict the atmospheres requested by the Client, were the starting point for this design, and from here, specific functions and departments were addressed independently within the look-and-feel of each wing (warm-cold).

Figure 1: GZH's Generic Atmospheres Scheme (Source: Adaptation and composition by author, 2018).

The KPG's colour and light plan, within one single interior area, identifies nearby locations to help the users with orientation and guiding. The parking was divided in two, longitudinally, into the themes of City and Sea that connect directly to their geographical location (Figure 2). This division is set on the underground level and reflects above ground on the main entrances (city colours and icons) and the secondary entrances (sea colours and icons).

Figure 2: KPG's Generic Atmospheres Scheme (Source: Author, 2018).

COLOUR – LIGHT – MATERIALS

The GZH's colour and light plans connects functionally with the psycho-physiological effects of colour, within a nature-based theme, in a way that it aids in the recovery and healing process of patients, as well as it improves the comfort and work process of the staff. The concept of creating a differentiation between the two main wings (H1 vs H3) is translated into the colour application, the light distribution, and shapes. On H1, the long corridors are fragmented in order to humanize the scale and to create focus of attention in important functional areas; while on H3, the longitudinal elements are emphasised by creating a perception of speed and efficiency (Figure 3).

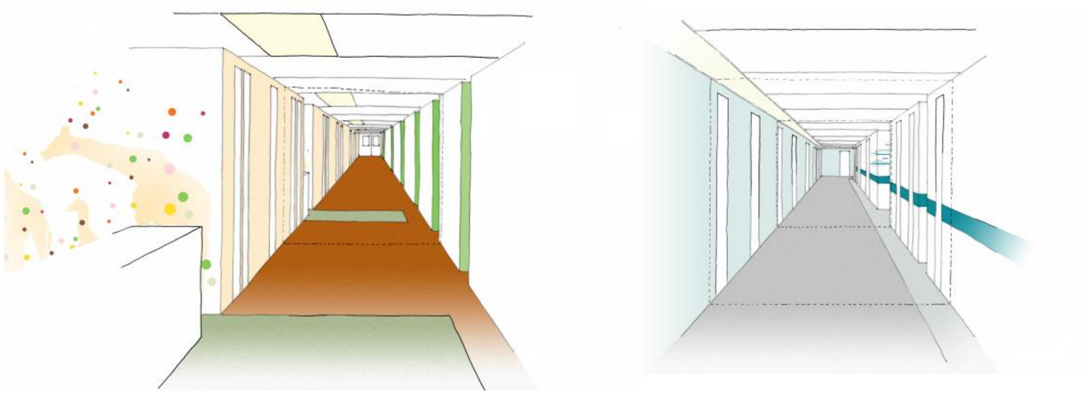

Figure 3: GZH's Atmospheres Concept Application H1 – H3 (Source: Author, 2018).

A holistic approach was achieved by having certain constant elements throughout, e.g. same colour flooring on corridors per wing, and white colour of main walls, doors, and ceilings. The colour differentiation per department was applied as following: corridors – one longitudinal wall of low chromatism, sets a mood and subtly identifies the department, while several transversal walls with a higher chromatic tone of the same colour break down the space and highlight room entrances; flooring **–** rooms have a different colour from the corridor with a tone that represents the department, whereas receptions and waiting areas have a more chromatic tone that extends into the corridor, making it visible from afar; prints **–** wall prints in receptions and waiting areas (H1) and nursing stations (H3) evoke nature figures relatable to the sectors' function. Figure 4 shows the policlinics, as an example for the overall concept applied in each hospital department.

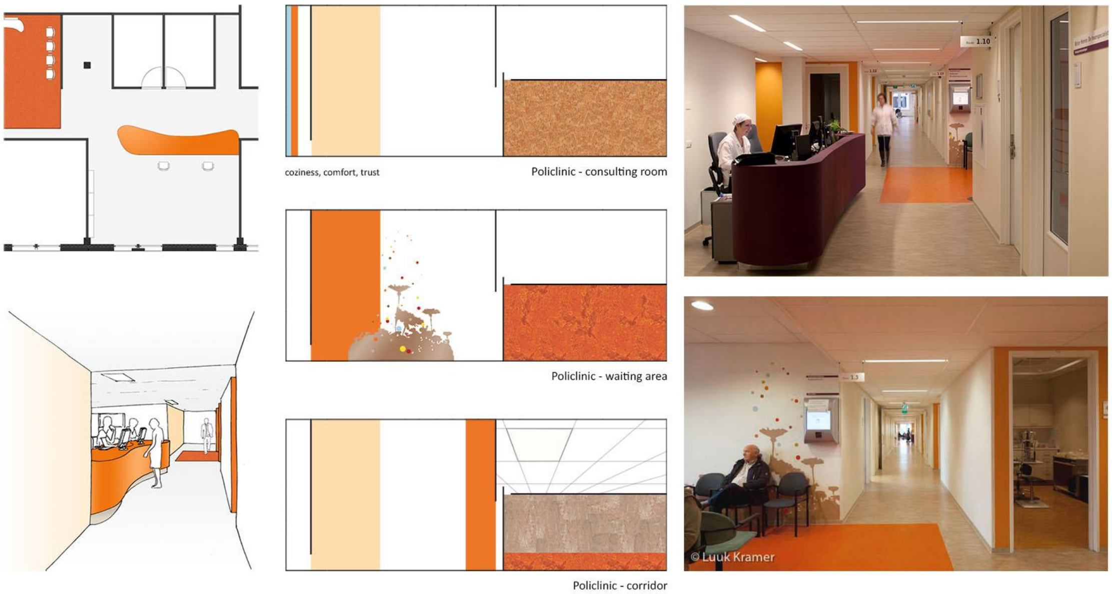

Figure 4: GZH's Materialization – Policlinics (H1) (Source: Composition by author, 2018).

Regarding the lighting concept, its application was made in the common areas and corridors only, with the rooms being out of scope due to the implementation of technical lighting. Through the emphasis on the fragmentation/fluidity of space: on H1 the recessed luminaires are squared reflecting the flooring patterns, in a rhythmic offset; on H3 the recessed luminaires are set in a continuous stripe that runs along the corridor, also reflecting the flooring design. In terms of materials and shapes, the custom-made furniture addressed the same concepts through haptic sensory stimuli. On H1, reception desks are made of a soft material (sponge with a hard paint coat) with organic shapes and the cabinets in the patient's rooms evoke wood's look and feel, conveying this wing's warm and welcoming sense. While, the desks at the nurses' stations are made of a hard laminate material with orthogonal lines translating the H3's colder, technical impression.

The KPG's colour and light plans are directly connected to the anthropological and cultural references of its location, and guides drivers and pedestrians, giving them orientation and information along the space. To this colour differentiation is added iconography referencing to Katwijk's architecture, beach culture, and other anthropological aspects, which are easily recognisable by its people – e.g. the iconic old church silhouette identifies the South entrance.

Colour and light are so blended in this project that it makes it difficult to describe one without the other. Focusing only on the colour expression, in order to help users identify their own (and their cars') location, as well as the garage's exits, the space was divided with cool tones that refer to the sea (West side) and warm tones that refer to the city (East side), combined with the colours fading in luminosity, from light (South side) to dark (North side). Also, the colour variations on the flooring identify different functions: in dark grey, road and parking places; in yellow, an accent colour, highlighting the disabled parking places and zones of caution circulation; and in white, information markings (Figure 5). The light plan has distinct concepts for the parking (basement) and the accesses (ground floor) – underground, the plan has functional goal, as it helps to orientate and locate, with information dispersed along the space; while on the ground floor, each entrance is shown in isolation, with the goal of identifying and differentiating each one, while creating a more poetic space. In terms of materials, the basement's light boxes are perceived as applied colour elements, seen from afar and in sequence, contrasting with the ground floor immersion of the users in a colour flooded space, achieved with a back-lighted perforated metal cladding that emanates the identifiable colour. As Safont-Tria (2012: 29) says “colour merges with light and generates a new ethereal effect on space”.

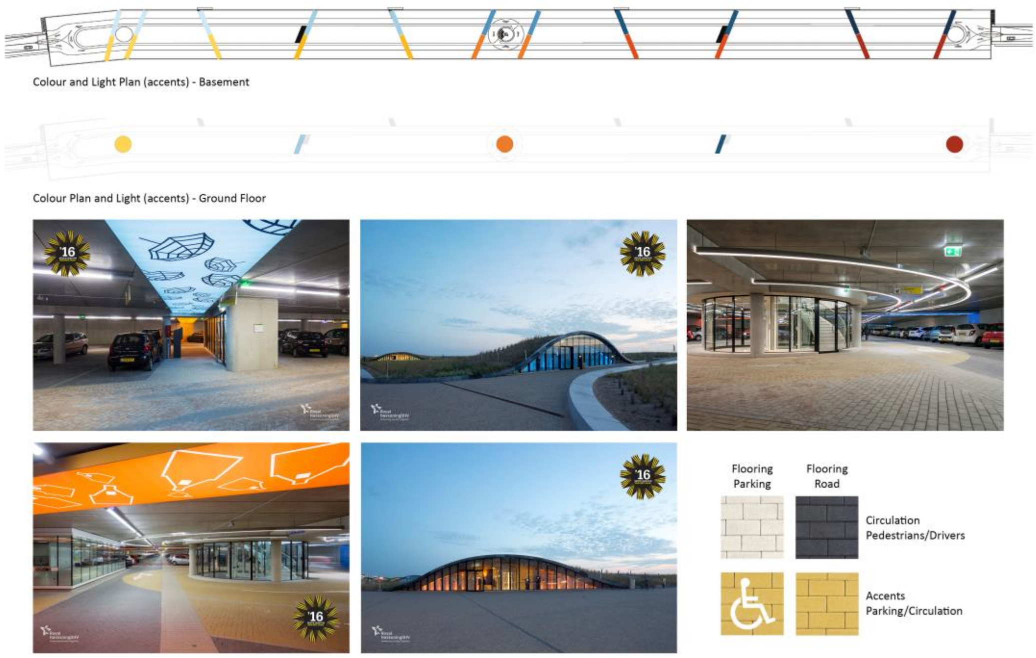

Figure 5: KPG’s Colour and Light Plans (Source: Composition by author, 2018).

CONCLUSION

It can be observed in this paper the three main aspects of conceptualization: **atmosphere** of the space, showing its personal connection to users; **orientation** of users in space; and, **communication** of information and functions throughout the space. It is also relevant to be aware that the introduction of the designer in an early stage of the project, where communication with the Client and the project’s architect was opened and clear, allowed the colour and light conceptualization to be reflected in the final product.

ACKNOWLEDGEMENTS

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Morphology of Contemporary Environmental Colour Design

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ABSTRACT

The main aim of this paper is to understand environmental colour design as a complex system and to find new descriptions of the variety of its morphologies. For studying the structure of environmental colour design, two types of methodological tools were used. Firstly, an online survey of colour professionals was carried out at the end of 2017. The total sample size of the online survey was 202 respondents (86 males and 116 females) from 35 different countries. Secondly, the study used quantitative content analysis of the AIC Congress and Meeting Proceedings over a 10-year period (between 2008 and 2017). Our analysis demonstrated the main focus of the environmental colour research and traced its changes over the time and countries. The fractal approach was used as a means to understand the diverse and vibrant content of environmental colour design as a system.

Keywords: *Environmental Colour Design, Fractals, Colour Research, Colour Systems, Morphology*

INTRODUCTION

Environmental colour design is a vibrant and dynamic phenomenon. Since its inception in the 1940s, it has experienced a wide range of changes and many new developments of its content, social functions and forms. Originally, the concept of 'environmental design' encompassed processes of human interaction with surrounding natural (e.g., geographical, solar, climatic) factors as entailed in the course of planning in such fields as urban planning, architecture, landscape architecture, and product design, which lead to manmade impact on the natural environment. More recently, the concept implies ecological and sustainable design efforts. And lately, in terms of developments in the field of colour, environmental colour design is playing a key role in creating the intended atmosphere in indoor and outdoor spaces. Its aim is to improve a sense of well-being and comfort through the construction of aesthetically appealing and environmentally friendly urban and residential facilities and public infrastructures.

The main aim of this paper is to understand environmental colour design as a complex system and to find new descriptions of the variety of its morphologies.

EXPERIMENTAL

For studying the morphology of environmental colour design we used two types of methodological tools, which provide complementary insights on fractality of the urban patterns.

Firstly, an online survey of colour professionals was carried out at the end of 2017. Participants of the online survey of colour professionals were recruited through an AIC (Association Internationale de la Couleur) Study Group on Environmental Colour Design (SG ECD) publicity campaign. The project was publicized internationally through the Study Group mailing list and website, social media channels (Facebook and Twitter), as well as through the partner organizations (AIC Study Groups on the Language of Color (LC) and Colour Education (CE), Inter-Society Color Council (ISCC)).

Secondly, the study used quantitative content analysis to investigate the meanings, themes and patterns of how different colour systems are applied in environmental colour design. We reviewed the AIC (*Association Internationale de la Couleur*) Congress and Meeting Proceedings over a 10-year period (between 2008 and 2017), treating particular elements of urban composition at different scales as integral parts of a whole sharing a common idea, examining their content regarding the goals, instrumentation, focus of environmental colour research, and traced their changes over the time and countries.

RESULTS AND DISCUSSION

The total sample size of the online survey was 202 respondents (86 males and 116 females) from 35 different countries located in North and South America, Europe, Asia, Africa and Australia. (Figure 1)

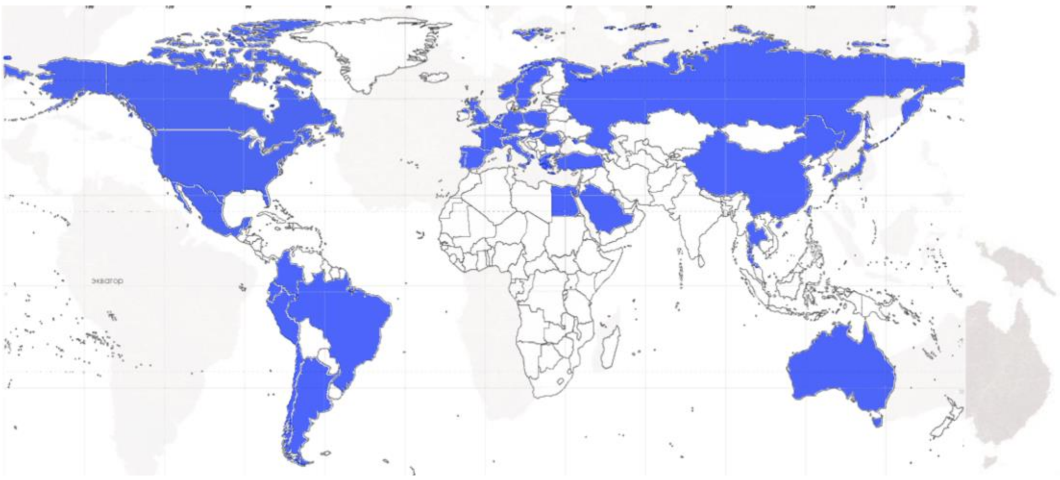

Figure 1: Geography of the online survey of colour professionals.

Participants were classified into three age groups: under 25, 25–50, and over 50 years. (Figure 2, left)

More than one-third of the respondents (39%) held a doctoral degree, 28% completed Master's and 18% Bachelor's programmes, and 14 % had different professional degrees (MD, JD etc.). (Figure 2, right)

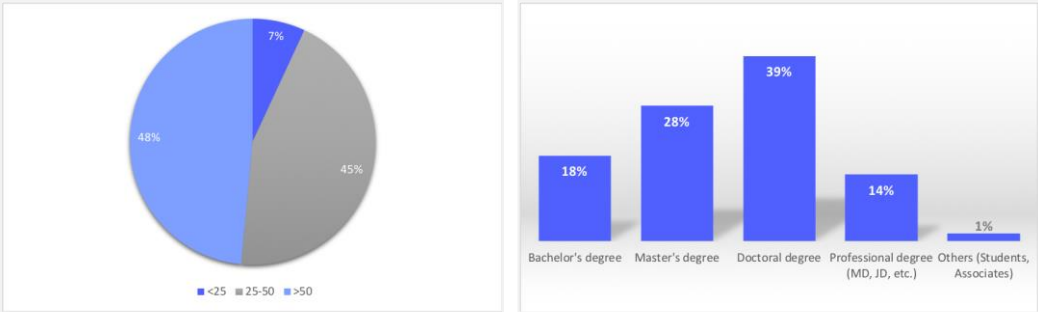

Figure 2: Participant age (left) and highest level of education (right).

Focused around a specific interest in colour as a means of environmental design, the range of professions of the survey participants was extensive and included colour consultants, architects, landscape architects, artists, designers, art historians, psychologists, educators, managers or directors of a colour institution, engineers, professionals with medical training, and more.

Only one quarter of colour professionals (25%) reported the use of one single colour system in their practice. (Table 1) Most of them used Pantone (9%) or Natural Colour System (8%). The overwhelming majority of those surveyed applied two and more colour systems.

Table 1: Experience with colour systems.

Colour system used in the prior research	%
Only Pantone	9 %
Only Natural Colour System (NCS)	8 %
Only Munsell Colour System	5 %
Only CIE	1 %
Only RGB	1 %
Only Colouroid	1 %
2 and more different colour systems	75 %

The list of colour systems named by participants included 21 different colour standards. The most frequently indicated colour systems were the Munsell Colour System (66%), the Natural Colour System (NCS) (61%), and Pantone (50%). (Figure 3) The top ten popularity rating also included RAL, Practical Colour Coordinate System (PCCS), CIE, Colouroid, Ostwald colour system, OSA-UCS (Optical Society of America Uniform Colour Space) and RGB.

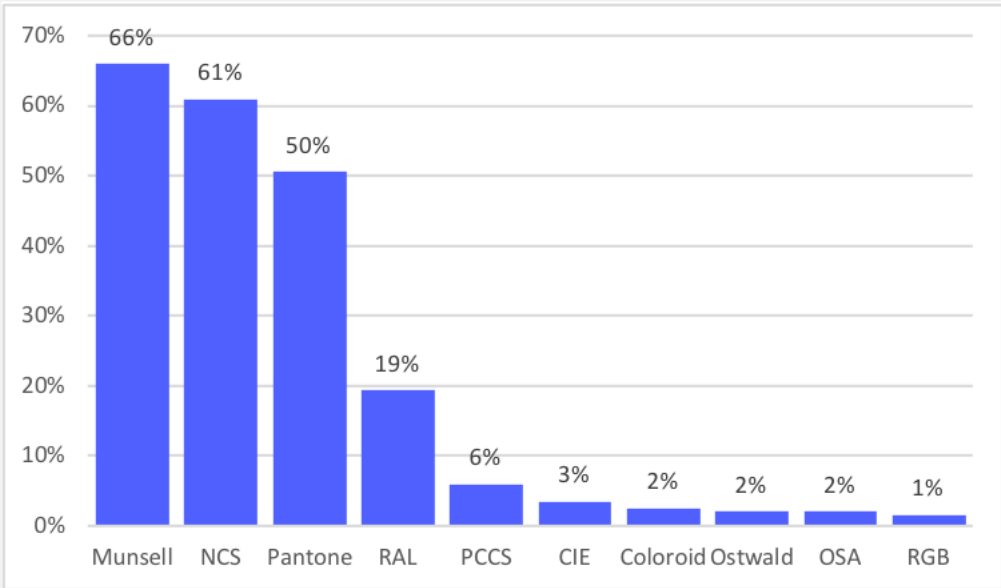

Figure 3: Frequency of use rating of different colour systems.

The high popularity of the Munsell colour system, revealed in this study, can be explained by the fact that the reported survey was publicized on the web-site of the Munsell Centennial Colour Symposium held in Boston in June, 2018 (www.munsell2018.org) to recruit participants and therefore attracted in particular the attention of colour professionals, who already had experience with the use of this colour tool in their previous research. We chose this most preferred colour system to further investigate the variety of morphologies of the environmental colour design, its meanings, themes and patterns.

To examine the main directions of the use of the Munsell Colour System either in theory or practice, we reviewed the AIC (Association Internationale de la Couleur) Congress and Meeting Proceedings over a 10-year period (between 2008 and 2017). At the first step of the content analysis, we selected from the total number of 2,122 papers published in the 10 proceedings books available at the Association Internationale de la Couleur web page (http://www.aic-color.org/congr.htm) 314 documents reporting the use of the Munsell Colour System. At the next step, we reviewed all the selected papers for their relevance for environmental colour design and found 90 relevant documents that we carefully examined to reveal the goals, instrumentation and focus of environmental colour research.

Our analysis demonstrated that the main focus of the environmental colour research included (1) interior; (2) exterior; (3) analysis of an existent environment; (4) colour planning; (5) colour design; (6) colour research experiments; (7) colour theory; (8) colour teaching. We also found that this main focus changes over the time and countries. (Figure 4)

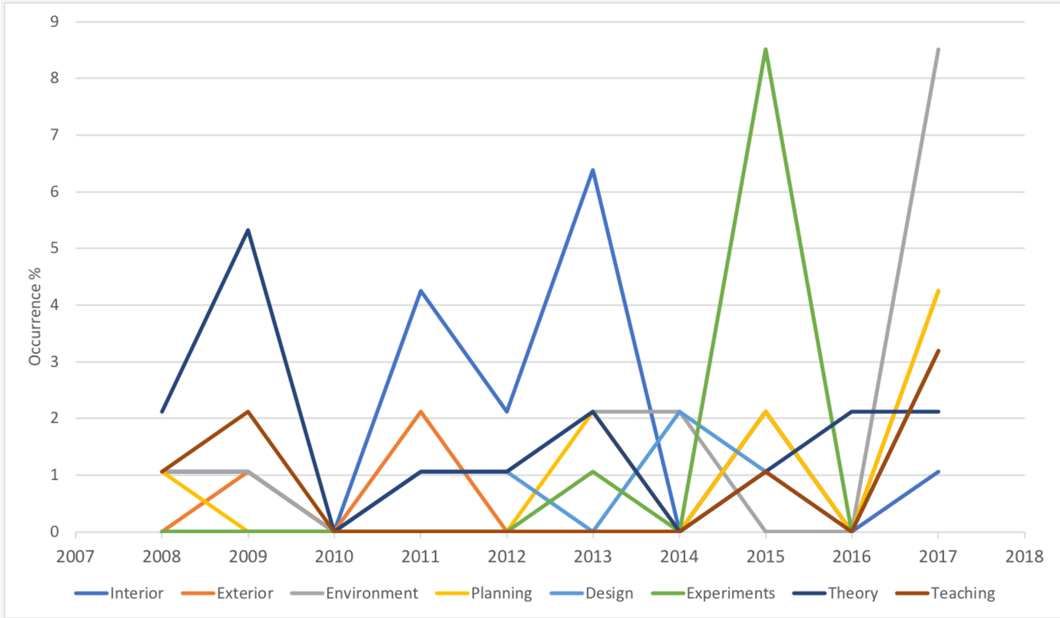

Figure 4: Changes over time in the content of papers applying the Munsell Color System in environmental colour design.

To understand the diverse and vibrant content of the environmental colour design as a system we used the fractal approach. Benoit B. Mandelbrot introduced the concept of 'fractal' in his French book *Les Objets Fractals: Forme, Hasard et Dimension* (1975) for describing spatial forms which are not regular and fragmented. Unfortunately, up to now there is no definition of fractals that is both simple and accurate. A fractal is defined as a special type of geometric figure, and the adjective '*fractal*' is the characteristic of a structure, phenomenon, or process possessing properties of the fractal (Zhukov & Lyamin, 2016). Mandelbrot himself defined fractal as a structure whose parts "in some sense" are like the whole (Mandelbrot, 1982). He used the neologism 'fractal' to point out its fragment structure and 'self-similarity' at different scales. Fractals are self-similar when the distance at which they are viewed is changed (McGraw-Hill Concise Encyclopaedia, 2008; Gleick, 2008).

CONCLUSION

The concept of fractal, allowing order to be perceived in apparent disorder, helps in re-defining the morphology of environmental colour design and a role of detail in its structure. It suggests that variation and fluctuation on all scales are important and related to each other. It allows the discovery of patterns and rules in the seemingly absolute chaos. It helps to understand that the research of environmental colour design includes a wide range of colour professionals of different ages, professions and cultures, with a focus on interior and exterior spaces, on the analysis of the existing environment as well as colour planning and design, and also on experiments, theory and teaching. Composition changes as we change our viewpoint, and new elements of the structure come into play.

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Chromatic Satiation and the Architecture of the American Diner (from "comfort food" to comfort space)

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ABSTRACT

The diner, the timeless restaurant archetype, supplies moments of solace to drivers along the vast highways of the American landscape. Although diners offer quintessential *comfort food* – satiating, warm, and filling nourishment – that makes a chilly night, a desolate freeway, or a lonely life path seem a bit less cold, diner design decisions drive messages of comfort long before a morsel of food is consumed. This paper explores how strategic use of the inherent color of materials in diner design communicates the concept of ***comfort***. As such, materiality in diners serves as messenger of contentment – not just to those hungry for food but to those hungry for comfort.

Keywords: *Color and era, materiality, restaurant design, Americana, car culture*

INTRODUCTION

Figure 1: Tick Tock Diner's famed sign attracts weary highway drivers with neon and chrome.

With immersive, sensorial use of materials, diners extend pleasures of home to regulars and one-time visitors alike as they offer spaces of predictability, openness, nostalgia, and pragmatism. Infatuation with diners began in the 1920s as increasing numbers of Americans took to the road in their new automobiles, and the diner culture craze continues to this day. Vibrantly colored neon signs, glowing yellow ambiance through planes of glass, and hot reflections of car headlights off of shiny silver diner exteriors beckon weary road travelers from miles during the dark of night.

RESULTS AND DISCUSSION

Time and time again, diners serve up a **predictable** interior environment in a restricted material palette. Staff and customers repeatedly volunteer that material choices in the diner typology – shiny chrome; slick cheap veneer (such as Formica); unapologetically faux leather; seamless stainless steel bent into Art Deco motifs of sunrays and curves; light-diffusing stacked glass block; multicolored ceramic tile; and vivid neon – exist so ubiquitously that their presence just “says diner” (Conversation 21 July). Acclaimed painter of diners, John Baeder, explains:

> The fascination comes from all the materials and textures and colors… painted in gold and crimson and azure blue… white porcelain with chrome hinges. Glimmering, shimmering stainless steel—inside, outside; wrap over and under, in and out. Mosaic inlaid tile… Glass… Gold-flecked Formica… (Baeder, 1995, p.16).

These distinctive materials greet customers in harmony with traditional understated, neutral, and crisp white short-sleeved button-down shirts under knee-length black omni-
present aprons that whisk about wiping down counters and attentively serving. Wait staff stay years if not decades and generally become career diner servers, well-acclimated to the specific axial layout in diner spaces. Not threatening and immediately familiar to the average American, diner spaces offer a comfortable consistency.

Yet, there is a bustle, an activity, a life inside this soothing shelter of predictability. In an insightful 1995 article, the New York Times exalted the “sights, sounds and smells of a good diner: ‘onion-laced hash browns sizzling on the grill; opaque coffee that flows like Niagara Falls and perfumes the air with the zest of caffeine; the clatter of thick china behind the counter; the hiss of Naugahyde upholstery when you ease down into a booth; and the rumble of trucks highballing on the highway just outside’” (Gabriele, 2013, p. 65). Customers can’t ignore the surroundings and didn’t come here to do so. Design elements amplify this **sensorial immersion** as shiny surfaces of chrome, plastic, and glass bounce light, color, and noise to magnify the goings-on. The heavy ivory white dishware highlights the ever-changing contours of food as it disappears from the plate. The tactility of cleaning cloth and spray on vitrines and scudding of shoes on the slick floor continally remind diners of the reassuring material presence of the space. As a result, the diner area is a zone of immediacy, a place of alert presence. Curves of the ceiling, flowing turns of the counters, rounded silver supports wrapping up and around cantilevering tabletops, and filleted tile edge pieces softening corners abound. Some designs exaggerate this sense of embrace; oft-cushioned backs of stools, exaggerated counter overhangs, supportive raised floor footrests, and tilted surfaces mimicking resting legs envelop customers. These rounded surfaces remain fastidiously wiped down in tune to a few quick sips of coffee or with the

Figure 2: Three conventional seating zones edge the narrow interior volume: countertop stools, intimate booths, and movable tables while stretches of windows let in light and allow reassuring visual access to the parking lot and highways. Formica veneer table surfaces, tile floors, faux leather benches, glossy curved ceilings, and gleaming chrome accents envelope the pill-shaped interior.

pleasant clicking silverware at a lingering Sunday meal (where shockingly few cell phones come out as people interact with each other instead of with their electronic devices). Smooth and not sharp, design elements such as these constantly stretch an encompassing feeling of immediacy and intimacy in the physical domain.

To longtime United States residents, diners inevitably bring up intimate spatial comforts of **nostalgia** as well: "… one tends to think of Baeder as a traditional colorist. He is painting landscapes not merely unified but modulated by light… It is full of sense of time, including the time of history" (Baeder, 1995, p. 6). Ironically, meaning of forms of early diner cars morphed from beginnings as pre-fabricated structures of Art Deco motifs symbolizing a spirit of forward progression of early 1900s technological innovations in transportation and transit networks. Now, diners mean nostalgia. In discussion of diners, staff and customers today immediately launch into persistently uplifting stories of their past—tales such as childhood jaunts with their father, middle-of-the-night high school food runs after going out late, and regular stops on motorcycle caravans trips. Research proves that positive memories of places tend to be more positive than they were at the time. In fact, one former regular customer said he used to go to diners after family funerals. Upon apologizing that I hated to bring up memories of death during my first-person research speaking with him, the regular corrected via text message, "Tick Tock [Diner] – I love it! Makes me think of family :)." Phenomenologist Gaston Bachelard in his seminal book, *The Poetics of Space* (1994, p. 6), attests, "We comfort ourselves by reliving memories of protection." Alas, diners continue to trigger joy and fond memories. In turbulent times of contemporary society, diners serve as a lingering, heartening connection to favorable moments of the past.


Figure 3: Surfaces raise, tilt, or extend in support.

Welcome in. Welcome back. Diners are **open** literally and metaphorically. Serving meals at all hours, diners extend a spatial welcome with shiny bright surfaces, easy navigation, natural light by day, and glow by night. A long-time waitress at Tick Tock Diner mentions that windows are key to diner design. Another adds that spatial openness separates the diner experience from that of other more traditional restaurants.

The long counter arrangement within the physically open space fosters the diner's seductive aura of **conviviality**. One customer notes that diners feel less authentic if counters are too short. Clearly, an abbreviated counter chops the space and makes the room feel disconnected rather than open. With rotating stools, counters not all that wide, a rather small distance between side-by-side customers, and a clear honest view of the food prep area, interaction with wait staff and customers at the counter abounds and serves as a

> backdrop to a host of adults who see the diner as their home away from home: the regulars, the men and women who sidle up to the counter and claim their stool… a community focal point… an image that has taken hold as an American institution. It is an image of the diner as a place where the displaced, the traveler, the lonely, and the new in town can feel a sense of belonging and recognition. It is a place where everyone can feel at home (Offitzer, 1997, p. 113).

This "everyone" includes variety of classes and ethnicities who pack diners, a **diversified setting** far too rare in many American establishments today. Attesting to the meaning-laden presence of diner counters, the 1960 Civil Rights Movement sit-in protest at a dining counter in Greensboro, North Carolina transformed and solidified this open and welcoming atmosphere of inclusion.

So, too, the **location** for passers-by of varied demographics just off the interstates remains ever convenient and openly receptive. Easily noticeable neon signs beckon those moving in vehicles at highway speeds. Baeder notes, "They reminded me of temples that had sort of shot up from the ground" (Offitzer, 1997, p. 101). Upon entry into the diner space, a customer encounters the choice of a clear direct path to the cook counter (and to the fat fluffy cakes in chromed vitrines much missed by a New Jersey native who had moved from the state) or efficient turns left or right to "cozy" booth and table seating (Conversation 02 August). The materials prove tough, durable, and easy to clean. The consistent shine of spotless surfaces encourages comfort and a belief in the existence here of needed nourishment of food and place. Since government agencies placed immigrants into cleanliness instruction camps (such as the American Club in Kohler, Wisconsin in 1918), Americans have been obsessed with **clean**, annoying even today's European transplants with addition of potentially toxic cleaning and preservative agents in a shocking number of products and foods (Sivulka, 2001, p. 115). The large windows offer a reassuringly safe visual sightline out to the highways and the parking lot. Diners have "come to represent what is simple, honest, and unpretentious about America's most popular eating adventure" (Offitzer, 1997, p. 48). Logical, economical, efficient, honest, clean, easy to access – diners encourage a comforting trust. Diner design provokes interaction to create places of comfortable classlessness, accessibility, social equality, and human contact. The message: Come on in. We're open.

CONCLUSION

Some people believe as we become more industrialized and separated from each other, there is a greater need to find the "homey comfort of a simple diner" (Offitzer, 1997, p. 4). In fact, 20-something aged adults, as a backlash to the overdone foodie movement of the past decades, gravitate to modest, straightforward eating establishments (Gabriele, 2013, p. 66). But, most importantly, in today's tumultuous times in the flawed social climate of an America in an increasingly conflicted world, designers can learn from the diner typology to suggest a comfort of consistent truths, acceptance, and openness in contemporary design. Architectural historian Vincent Scully remarks that, in the paintings of John Baeder, "diners fit into their urban context like modest folk heroes" (Baeder, 1978, p. 6). Diners persist as icons of reprieve from monotonous hours on the road, from difficult encounters in life, from hollow hours in politically fraught times. The diner perseveres as an "artifact of American optimism" (Gabriele, 2013, p. 65). In fact, a woman sitting at the counter of a New Jersey diner – the woman who attested that the traditional material palette just "says diner" – confided to me that she had just emerged from chemotherapy treatments. The diner was the first place she went when she hadn't eaten for days.

 

Figure 4 at left: Bendix Diner remains as a pre-fab structure from decades ago. It faces the parking lot and highways, offering an invitation – even on a cloudy day – with its wide windows, broad exposed facade, easily distinguishable entry, and neon framing.

Figure 5 at right: A view from the front of Bendix Diner showcases the highways framing a convenient parking lot, attesting to the diner's accessibility for truckers driving grueling days.

ACKNOWLEDGEMENTS

Thank you to the generous staff and customers at the New Jersey and New York diners visited. Special gratitude is extended to the unstoppable waitress – aged 75 – who has been working at Bendix Diner for 37 years and the insightful customers flanked by meticulous staff who serve a remarkable burger and disco fries at Tick Tock Diner.

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AIC LISBOA 2018
colour & human comfort

Defining industrial environments through colour and light

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ABSTRACT

Essential to the overall perception of the environment and its relationships, colour and light contribute to the creation of form and organization of industrial space. In fact, their influence on the human being is a complex and current issue. This paper explores the thought and method underlined in four projects of industrial architecture in Europe (*Usine Claude et Duval*; *Panificadora de Chaves*; *Magnum Energiecentrale van Nuon*; *Manifattura Berluti)*, and aims to identify their differences and particularities, adding new methodological directions, which in turn help professionals from various fields to further expand the discussion of colour and light as instruments of comfort and humanization of industrial spaces. We propose and demonstrate four non-categorical principles about colour and light: variations of hue, pattern and texture; the use to conform and transform features; the ethical and aesthetic connotations; and the improvement of the spaces.

Keywords: *colour-light-senses; comfort; wellbeing; industrial spaces*

INTRODUCTION

Industrial buildings have been developed for years, crossing different generations. They don't only occupy the place they are rooted at but they end up characterizing it. In fact, industrial buildings have a set of technological, architectural, sociological, and cultural values, which make them a living testimony of an era.

Even though recognised by several authors, the importance of articulating theoretical knowledge with practise has verified a dichotomy between the design process and the reality of experiencing spaces, a dichotomy between the definition of industrial environments and the perception of colour and light.

It is important to understand the motivations that underlie the conception of industrial spaces that create new practices of representation of light and colour, based on the human body and its awareness through the entire sensory-perceptual system.

For this analysis it was developed the following tasks: a) collection of relevant information to the research (literature review, exploratory research of the case studies); b) analysis and structure of the information (design of an analytical chart that systematizes the chromatic composition, description of relevant aspects that express the intentions by the architects); c) Interpretation and critical discussion of the results while assessing the validity of some concepts commonly linked with colour and light.

Starting from these considerations, in a first stage are established the fundamental theoretical assumptions to the contextualization of the problematic; and in a second phase, as referring to the interventions of the architects and designers, aims to find characteristics, which contribute to the definition of the environment, and processes that have been used to improve the interaction with the human being.

COLOUR, LIGHT, AND SENSES

Evidenced or stigmatized in different cultural, social, or historical contexts, the senses contribute to the overall experience of an environment. Through the senses, each human being interacts, among other things, with the environment and determines its individual and collective condition.

> They convey information and contribute to our appropriation of the environment by means of sensory impressions and experience: we can perceive, experience, recognize, evaluate, and design the environment and ourselves. Each sensory organ has a specific structure that enables it to respond to a specific sensory stimulation.
>
> (Meerwein *et al*, 2007: 13)

Throughout history, the distinction of the five senses (sight, hearing, smell, taste and touch) has been considered in various societies (Jütte, 2005). However, recent studies of different disciplinary areas have shown that the human-environment relationship is being based on other senses as well. As Steiner (1981) illustrated, and later expanded by various authors including Meerwein *et al* (2007), the twelve senses can be enumerated and organized in three genres: action, impression, and meaning.

The four physically oriented senses, or with greater interiority (touch, life/comfort, movement, and balance), are characterized by will and action. The four mentally oriented senses, or with greater exteriority (smell, taste, sight, and warmth), are empathy and impression-oriented. The four immateriality oriented senses, or with greater spirituality (hearing, speech, thought, and self), are meaning and recognition-oriented.

In the combination of these perceptual systems lies the basis of the sensory and existential experience of the human being. In this matter, colour and light have a fundamental role for the human being to sense and perceive the built environment, which can influence the behaviour, the decision-making, and wellbeing, or improve health, comfort, emotion, and feelings (Mahnke, 1996; Durão, 2005; Meerwein *et al*, 2007). That is, colour and light create subtle stimulations with relevant impact that have been psychologically, physiologically, and sociologically affecting the human being.

INDUSTRIAL SPACES: CASE STUDIES

Studying the influence of industrial spaces of low, medium, and high production on the human being is a complex and current issue. Within this challenging context, the research set out to take a multi-dimensional view of the built environment sought to identify the differences and particularities in an international context. Therefore, the research draws particularly from the methodology of four projects of industrial architecture in Europe (Table 1).

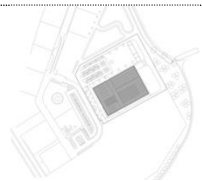
	Usine Claude et Duval	**Panificadora de Chaves**	**Magnum Energiecentrale van Nuon**	**Manifattura Berlutti**
Site Plan				
Author	ATBAT / Le Corbusier	Nadir Afonso	Royal HaskoningDHV	Barthélémy Griño Architectes
Location	Saint-Dié, France	Chaves, Portugal	Eemshaven, The Netherlands	Ferrare, Italy
Project Year	1946 – 1951	1962 – 1964	2006 – 2013	2012 – 2015
Client	Jean-Jacques Duval	João César et al	N.V. Nuon Energy	Berlutti S.A.
Area	1.225,50 sqm	1.590,00 sqm	12.000,00 sqm	7.890,00 sqm
Function	Textile	Bread	Energy	Shoe and Leather Goods / Académie du Savoir-Faire
Floors	1 below ground 4 above ground	1 above ground	1 below ground 4 above ground	2 above ground

Table 1: Project's Description Synthesis. (Source: Author, 2018).

Notwithstanding of the era in which each of the case studies were built, the selection took as a starting point the following criteria: the different geographic locations with a preponderant role in the social, urban, rural, and architectural context; the authors' contributions to the study of the materiality of light and colour; the subsistence of its respective use (even though some changes have been made, they have not distorted its initial concept); and, the concern with the humanization and comfort of the space.

MATERIALITY PRINCIPLES

In *Usine Claude et Duval* it was developed a chromatic system laid in the principles of the "Le Modulor", and under influence of Bauhaus (Duval, 2006). That is, colour harmonises and sets the rhythms and proportions of form, giving it plasticity according to three principles: functional – identification of infrastructures; environmental – producing specific ambiances in areas of permanence; and, transitional – highlighting objects or dynamic elements of architecture.

The natural and artificial light safeguards the comfort and wellbeing. The roughness of the materials contrasts with chromatic tones in ceilings and infrastructures (Table 2A - Exterior / Interior).

The overall design principle of *Panificadora de Chaves* creates a harmony that holds form and colour together, and accentuates the potentiality of natural light (Cepeda, 2016). This language enters in an abstract domain between visible and invisible, and expresses a functional aim, gathering easy maintenance and cleaning, among other characteristics.

The painted surfaces in the exterior with less chromatic tones revealed an iconic presence, which is recognisable in the city (Table 2B - Exterior). While, in the interior, colour affirms its presence through two principles: environmental – producing specific ambiences in areas of permanence; and, ephemeral – creating with light different atmospheres in the work environment. These principles stimulate harmony between the materials and identify different uses (Table 2B – Interior).

Typology		Exterior							Interior						
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
[A]	[NA]														
[B]	[NA]								C02 I09 I05 I06 I07 I08	C01 C02 I04 P02 W01	G01 I04 W04 W05 W01 I05 W06 W07	P01 C02	C02	C02 I04	M02 M03 M03 M04
[C]	[NA]									P01 C01	G01 I05 W06 W07	C01 V01	P01		
[D]	[LP]	C01 P01 P02 P03	C01 C02 M03 C03 S01 S02	G01 I01 W01 W02 W03 I02 I03	C02	C02 C03 C04 C05	C02 I04	I04 W01 I05					P01	P04 W01 P03	
[D]	[MP]								C02 I04 I05 I06 I07 I08	P01 C02 S02	G01 I01 I04 W04 W01 W06 W07	V01 V04	M02 B01	P04 I04 W01 F04 F05	
[D]	[HP]												C01 C06 C03 C07 C04 C08 C05	I01 I04 F02 W01 F05	
[E]	[MP]								C02 I05 I06 I07 I08	G01 P01 P02 P03 P04 P05 P06 P07		V01 V02 V03	P01	M02 F01 F02 F03 W01 F04 F05	
A – Usine Claude et Duval (UCD)															
[A]	[NA]														
[B]	[NA]									R01	G01 W01 W02 W03 W04	M02			V01 V02
[C]	[NA]									R01 C01 C02					
[D]	[LP]	R01 I01 R02 R03	R01 R02	G01 G02 S01 G03 I02 S02 G04	C02	R01 I04		W01 W02	S07	R01 R02 C01 C03	W01 W03	M01	R01		
[D]	[MP]								S03 S04 S05 S06 S07	R01 R02 C01 C03 C04	G05 W01 W05 W04	M01 M03			V01 V02 V03
[D]	[HP]														
[E]	[MP]								S07	R01 R02 R03	G05 W05 W06	M01	R01 R02	W01 W05 W04	V01 V02
B – Panificadora de Chaves (PC)															

Legend: [1] Function | [2] Production Levels | [3] Structure / Infrastructures; [4] Walls; [5] Gates / Fences / Doors / Windows / Handrails / Hardware; [6] Floors; [7] Roofs; [8] Product Design; [9] Communication Design / Plastic Arts; [10] Structure / Infrastructures; [11] Walls; [12] Doors / Windows / Hardware; [13] Floors; [14] Ceilings; [15] Product Design; [16] Communication Design / Plastic Arts; [A] Expansion Spaces; [B] Circulation; [C] Services; [D] Production; [E] Logistics / Administration | [NA] Not Applicable; [LP] Low Production; [MP] Medium Production; [HP] High Production

Typology		Exterior							Interior						
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
[A]	[NA]														
[B]	[NA]														
[C]	[NA]														
[D]	[LP]	C01	G01 C01 P01 M02 M03 M04 M05 M06	G01 M07 W01 M08 M09	C01 T01 E01	S01 S02 W01 T01	M01 M10 M02	V01 V02 V03 V04 V05 V06							
[D]	[MP]								M11 M12 M13	C02		M14	C01	M02	
[D]	[HP]														
[E]	[MP]									C01	G01 C02 W01	V01	C01	F01 W02 F02 W01	
C – Magnum Energiecentrale van Nuon (MEN)															
[A]	[NA]														
[B]	[NA]									R01 W04	G01 A01 L01		W01	L01	
[C]	[NA]										W02 W01		R01	W02 W03 W01 W04	
[D]	[LP]	I01	W01 W02 W03	G01 A01	S01 C01 T01	C01		W01 W02		R01		W01			
[D]	[MP]										G01 W02 W01		R01 C01		V01 V02 V03
[D]	[HP]								I01	R01 W01	G01 A01	T01	W04 C01		
[E]	[MP]									R01	G01 W02 W01	W01	R01 C01		
D – Manifattura Berlutti (MB)															

Table 2: Materiality - colour, texture, pattern. (Source: Author, 2018).

In *Magnum Energiecentrale van Nuon* the colour plays an aesthetical and functional duality, in order to, minimise the visual impact of the factory on the landscape, impart information, add orientation, and improve the work conditions of the users (Santos, 2009).

The method for designing is mostly based on the differentiation of the factory's process and non-process zones. That is, the exterior (process zone) is materialised with cool tones that refer to the North Sea and surrounding terrain (Table 2C – Exterior), and spread from dark (dirty – raw materials) to light (clean energy). In the interior (non-process zone / building) the natural and artificial light define visual ambience, comfort and visibility, and the materials express chromatic/achromatic contrasts (Table 2C – Interior).

The *Manifattura Berlutti* emphasizes the craftsmanship and it is a metaphor of the *Berlutti* brand (Griño, 2016). As a shoe manufacture gesture, the plastic qualities of materials aging are valued, awakening the senses to an objective and subjective relationship with time, space and nature (Table 2D - Exterior).

In addition to other factors, colour evidenced by natural and artificial light, restores the comfort and environment quality of the different space uses. In this relationship, natural and manufactured materials are used as a means of humanizing the space, following three principles: environmental – producing specific ambiances in areas of permanence; transitional – highlighting objects or dynamic elements of architecture; and, ephemeral – creating through light different effects (Table 2D – Interior).

CONCLUSION

This research reveals that the way the human being use space is not conditioned exclusively by their form, but also by the environmental and functional qualities associated with it.

Confined the programmatic contents that give them context and attribute meaning, in each case study is explored and developed the body dimension and the interaction of the senses with space. In this dialogue, the principles of materiality are based on human and ethical values, build on the spatial experiences that synthesize artistic sensitivity, technical, environmental and social responsibility.

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colour & human comfort

The Governance of Light: Wellbeing and current practices of public lighting in Lisbon

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ABSTRACT

This paper focuses on the impact of artificial lighting analysing the influence of light pollution on well-being. The background is United Nations' 2030 Agenda and the much needed articulation between Good Health and Well-being (goal 3) and Sustainable Cities and Communities (goal 11). In particular we address the health impact of LED lighting use in the built environment, particularly in the circadian rhythm (a 24-hour cycle that responds to the light-darkness cycle, responsible for regulating body temperature, sleep, hormone production, eating patterns and neurological stability). Taking Lisbon as a case study we suggest future guidelines that balance both current energy saving requirements and lower CO2 emission, and well-being and health.

Keywords: *LED, public lighting, urban, health, sustainability*

THEORY

1. The mesopic paradox, LEDs and 'the blue light hazard'

We can distinguish between three types of vision: photopic, scotopic and mesopic. Photopic vision facilitates excellent colour discrimination ability, it occurs when cones are mainly active, which is in daytime. Scotopic vision occurs when rods are particularly active being active in dim conditions and colours are indiscriminable though one can see contours and shapes. (Schreuder 2008, Ch7) In between photopic an scotopic vision there is not a specific transition luminance value but there is a zone called mesopic vision. At many night-time levels, a combination of both cones and rods supports vision. (Schreuder 2008: 237)

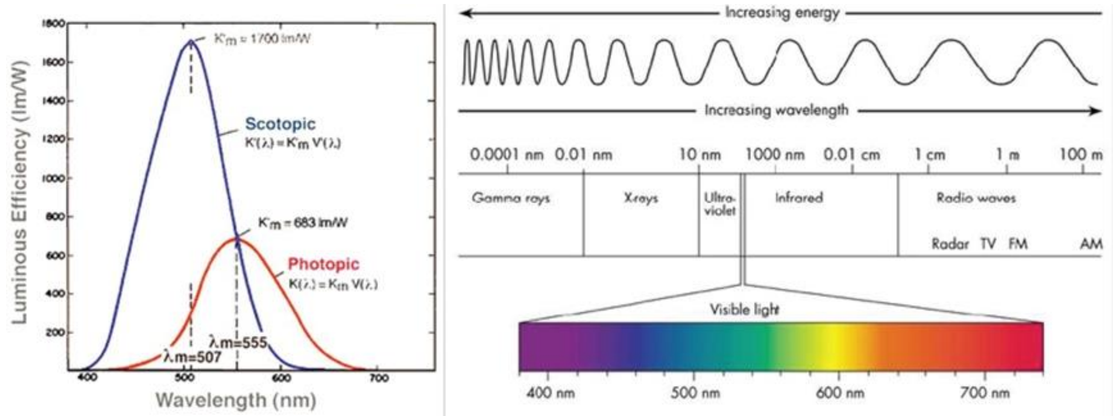

Fig 1. Image found at Lighting Analysts Inc (2017) (left). Image found at Munsell Color Website (right)

It is known that a white LED at colour temperature (CT) 4000K or 5000K contains a high level of short-wavelength blue light. An incandescent bulb has a colour temperature of 2400K, which means it contains far less blue and far more yellow and red wavelengths. Before electric light, we burned wood and candles at night, which has a CT of about 1800K, quite yellow/red and almost no blue. (Stevens 2016) According to the Federal Public Service Health - Food Chain Safety and Environment in Belgium, blue and cold white LED lamps emit relatively large amounts of blue light, which may pose a health risk ("blue light hazard"). (FPS 2016) However, among the light types used for street lamps, light-emitting diodes (LEDs) are expected to become globally predominant within the next few years. Can LEDs in the context of urban environment have a negative impact on health?

2. On LEDs sustainability: energy saving vs health? The circadian rhythm

It is well documented and fully established that in the context of built environment, LEDs can effectively contribute to reduce expenses while promoting energy efficiency.

But being LED an unequivocal energy saving option, can we say it is a sustainable one if it hinders human health?

The European Commission has created the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) and light sensitivity, artificial light (SCENIHR 2008, 2009, 2012) have been addressed in the past. Blue light and ultraviolet radiation was acknowledged as a potential risk factor for the aggravation of the light-sensitive symptoms in some patients with such diseases as chronic actinic dermatitis and solar urticarial. As of 1 September 2018 energy intensive and inefficient halogen light bulbs will no longer be sold across the European Union. Originally decided in 2009 by the Member States and the European Parliament (Commission Regulation 244/2009) as part of the EU's Ecodesign Work Programme the main goal is to promote energy savings and reduce CO2 emissions. In June 2018, as part of the Clean Energy for All Europeans package, co-legislators reached political agreement on a new 32.5% energy efficient target for 2030 (European Commission 2018)

In 2018, SCHEER (ex-SCENIHR) emitted a report on LEDs. It states that: "The currently available studies indicate that artificial light can influence the circadian system, depending on the light characteristics. (…) Exposure during the evening might result in changed sleep patterns and other adverse effects, although evidence is limited. (…) However, the current conclusion is based on a limited amount of studies, which were mostly performed in a laboratory setting. An important question that remains is whether light from LEDs and artificial light in general, present in indoor lighting and screens, will have an effect on the circadian system in real life. Moreover, it is currently unknown if the effects on the circadian system remain, enhance or reduce, after repeated and ultimately after chronic exposure, such as currently occurs in real life." (38)

The statement is surprising in the face of hundreds of published research that confirm that LEDs do impact the circadian system (eg. Duffy & Czeisler 2009, Fonken et al 2013, Dominoni et al 2013, Kenneth et al 2013, Wright et al 2013, Stevens 2016, Zielinska-Dabkowska 2018). Recently, Barry Clark (Colour Society of Australia) also concluded that LED use in public lighting hinders human health. (Clark 2018) It can also have a negative effect on the elderly population (Hatori et al 2017) because it changes melatonin levels. It can also have an impact on mental health (Lewy et al 1985, Srinivasan 2006, Stevens 2009, Chepesiuk 2009, García-Blanco 2013) — particularly bipolar disorder, major depression, autism and premenstrual dysphoric disorder (Lewis 2014: 498).

Back in 2016, the American Medical Association (AMA) issued a statement on recommending that outdoor lighting at night, particularly street lighting, should have a color temperature of no greater than 3000 Kelvin (K). A white LED at CT 4000K or 5000K contains a high level of short-wavelength blue light; this has been the choice for a number of cities that have recently retrofitted their street lighting such as Seattle and New York. The new "white" LED street lighting, which is rapidly being retrofitted in cities throughout the country, has two problems, according to the AMA. The first is discomfort and glare. The other issue addressed by the AMA statement is the impact on human circadian rhythmicity. (Stevens 2016) The most recent recommendation for CT, in article published by Nature, is no more than 3000K (Zielinska-Dabkowska 2018) which is in tune with the intention voiced in 2014 by Lisbon's City Hall (ADENE 2014).

It is therefore puzzling that, despite also claiming that more work on this subject is needed, SCHEER's 2018 report states: "Many street lights and other street fixtures are being converted to, or replaced with, LED lighting. The main driver for this is energy saving. However, if this factor alone is considered, there are claims that LED lighting may be installed that is poor quality in terms of the emission spectrum, illumination, light pattern and glare. Moonlight has a CCT of about 4000K, so it could be argued that artificial street lighting should not exceed this value. However, it is important that the lighting installation is appropriate for the use of the road (e.g., motorways may justify higher CCT lighting than residential roads)." (40,41)

We have already addressed that there are concerns when it comes to the difficulty of measuring LED light. To this, we add that colour temperature reliably predicts spectral content of light. "However, the CT rating does not reliably measure colour from fluorescent and LED lights. Therefore, the AMA's recommendation for CCT below 3000K is not quite enough to be sure that blue light is minimized." (Stevens 2016) Therefore that 4000k suggested value based on moonlight (a completely different light source other than LED) sounds surprisingly light-hearted.

Henckel & Moss (2015: 302) have claimed that both the Ecodesign Directive (that aims for the use or exclusion of certain technologies) and the norm DIN EN 13201, (recommending minimum lighting levels fro street lighting) show that "the lighting industry is effectively ensuring higher lighting standards that would increase, rather than decrease, lighting levels." This seems to illustrate what we suggested above, that when it comes to lighting, individual and collective interests may collide.

LED lighting is being widely implemented worldwide. New York and Seattle have implemented it. In Los Angeles, the LED Streetlight Replacement Program has replaced over 140,000 existing streetlight fixtures in the city with LED units over a four-year period. It is reported to have promoted energy efficiency CO2 reduction, reduced sky glow at night, and reduced light pollution. (Bureau of Street Lighting 2018) In India, the government of Karnataka, Vishakapatnam in Andhra Pradesh, Jhalawar in Rajasthan, South Delhi Municipal Corporation, Aiappuzha in Kerala, Agartala in Tripura, Aligarh in Uttar Pradesh and some other cities have also already moved forward on this initiative. Let us now address Lisbon as a case study.

EXPERIMENTAL

According to *Plano Nacional de Acção para a Eficiência Energética (PNAEE) - Resolução do Conselho de Ministros n.º 80/2008, in 2014*, it was reported that public lighting replaced mercury lighting for by sodium vapour lamps in 2644 lamps leading to a saving of 911kWh/ yr and €81,000. It also started investing in more technologically advanced control systems. (CML 2014)

But that same year LED was already part of Lisbon's street lighting. João Oliveira Nunes from the public lighting department at Lisbon's City Hall, suggested a potential energy saving of 49,47% due to the implementation of a project pilot in Lisbon (Alameda Edgar Cardoso, Amália Rodrigues Garden, Joaquim Marques Leitão Street and João Barreiros Street in Lumiar). The replacement process started being tested in 2009 and main concerns were avoiding flickering and colour temperature. Nunes, stated that the temperature being implemented was 4000K but that in the future it was going to drop to 3000K or 2700K in order to achieve a warmer white. The main reason was because, particularly in historical neighbourhoods, people are extremely wary of white light. (ADENE 2014)

In December 2017, right-wing party CDS-PP presented a proposal at Lisbon's City Hall (Moção 46/ 2017) suggesting that LED should be implemented in main streets and tunnels and also in Lisbon's financial centre (Saldanha/ Picoas). Two studies were approved in order to clarify the best way to do this. All parties favoured the proposal unanimously. Out of the 4.976 lamps, 4.648 will be replaced by LED lighting. Carlos Moura (Communist Party) defended that warm white should be used. Ricardo Robles (far-left party, BE) claimed that CT was not relevant because people would end up getting used to it and energy saving was the priority. (Lusa 2017) Below are two examples of LED implementation in a city centre residential area (Arroios).

Fig. 2 Estefânia's Playground (Rua D. Estefânia, Lisbon). September 2018. Photo credit Diana Soeiro

Fig. 3 A,B,C,Praça do Chile's Square parking lot (LED lighting);D,E, Avenida António Pereira Carrilho (transition area with halogen and LED);F,Largo do Leão (LED lighting). September 2018. Photo credit Diana Soeiro

RESULTS AND DISCUSSION

A brief addressing of these two scenarios reminds us that optic covers should be considered in order to better LEDs performance (Gago-Calderón et al 2018) and that pedestrians and citizens comfort levels in public space should be further investigated - which has been heavily neglected up until now in favour of energy saving arguments (Hölker & Tockner 2010, Kostic & Djokic 2013, Network Loss of the Night Network funded by EU-COST Action ES1204). Furthermore, at the time the picture was taken, we observed that in the playground there were eight people who choose to sit in the least illuminated area. In the parking lot, it is clear that LED has a stark shadow with no gradation (a phenomenon known as *umbra*, Latin for 'shadow') contrary to other types of artificial lighting that mimic the gradation of natural light (*penumbra*, Latin for 'almost'), offering a softer transition from illuminated areas to darkness. The lack of *penumbra* is among the main reasons why LED is detrimental to our perception and ultimately, to our health. (Pernão 2017)

CONCLUSION

1. A broad concept of sustainability is at stake when it comes to LED. Energy saving, municipal reduced expenses, and lower CO2 emissions should not be achieved at the expense of health damages. Along with AMA (2016) we claim that it is encouraged that communities minimize and control blue-rich environmental lighting by using the lowest emission of blue light possible to reduce glare.
2. Impacts on culture, society, human health, economy, ecology, and coupled natural-social systems should be addressed when it comes to LED lighting in the built environment. Instead the logic of 'do it first and think about the impact later' is clearly prevailing and that can have severe consequences. Or, to say least, it can have consequences that we do not know yet.
3. A major objective of LED lighting manufacturers is to maximize energy efficiency of the installations generated by their products. However, LED technology does not have to be perceived as a 'bad' technology. It is not a matter of 'LED vs health'. It all depends on how you use technology — and on that urban design is key.
4. Different areas of the city have different needs. In urban design there is a difference when dealing with narrow or wide streets; with monuments; residential; commercial; highways; rural or urban areas. Scale, colour and luminance need to be addressed accordingly.
5. Lighting, in particular street lighting, requires interdisciplinary cooperation. Especially when a commanding technology like LED is available and a tendency to use too much light is observed.

Hopefully, in 30 years' time, the streets will be nicely lit — better than today — but we will use one-tenth of the light. (Irwin 2018)

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The role of environmental colour in the experience and identity of the city

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ABSTRACT

In the last decades the city has become a main issue of debate in different disciplines. In fact, the city has become the best laboratory to test all the processes involved in the transformation of contemporary cities. Actually, the construction of the present city and its spaces make up a complex but appropriate performing context to reflect on the city, its spaces and the relationship with experiences in the present society. In this context, the role of environmental colour is essential since it suggests environments that promote ways of understanding and experiencing the space being this a primary element in the strengthening of urban life and the construction of the identity of the city.

Keywords: *environmental colour, urban experience, chromatic identity, contemporary city*

INTRODUCTION

At present, the discussion of the urban space and the city is considered a priority. The combined impact of worldwide phenomena such as the globalization and the development and evolution of technologies plus the local ones, for example the changing socio-economic-cultural context in Latin America, makes us focus on the transformations in the urban space that have taken place specially in the city of Córdoba, Argentina.

The sense of colour and the chromatic environment are part of the urban experience and participate in everyday city life. The environmental colour, that unique and general chromatic impression of the urban environment, has shared and taken part actively in the changes of societies that become evident in different ways in the city and its places.

Within this framework, the intervention of environmental colour is essential. The communicative aspect of colour has been enhanced by new ways of production and physical and digital resolution systems and these, in turn, have increased its capacity to inform, suggest and develop synesthetic associations and create environments bringing about the experience of the city and the promotion of urban life which are vital for its identity, design and construction.

THE CONTEMPORARY URBAN CONDITION

The problems concerning the urban space is the issue of an ongoing debate in different disciplines. The various perspectives and viewpoints as regards the features of the contemporary city focus particularly on the meanings of the urban, the public or collective in societies, among others.

The present urban condition in search of a multidimensional light on the city presents two ways to consider it. On the one hand, an urban condition of corporal and experienced sense exemplified in an ideal kind of city connecting the physical-spatial with the mental-imaginative, such as European cities or the traditional Latin-American one. On the other hand, an urban condition intertwined with new technologies, communications and global deals which place flows before places expressed by the so-called global cities and contemporary megalopolis. In this context the so-called urban conditions confronted in a game of tensions focus on considering the nature of the urban experience with the purpose of recovering it in a broad sense, and more specifically, as a sense of place that is essential for urban life (Mongin, 2006).

Figure 1: The Chromatic Expression in The Contemporary City. Córdoba, Argentina.

There are new ways to use the traditional urban spaces and new collective uses that presume a change in the concept, image and value of the urban space and therefore, of the city. The urban experience and the sense of belonging of the inhabitant with his city are modified by socio-cultural or environmental conflicts, among others (Arroyo, 2011). To sum up, the city as a collective place, public event or social life environment expresses evident changes in the urban space which reinforce the idea that this space matches the ideas of the “city” according to different times. Moreover, the idea of inhabiting keeps its meaning since the urban experience is mainly the combination of physical and mental facts not only material but imaginary as well.

URBAN ENVIRONMENTAL COLOR

The colour in the city appears as essential information that stimulates the perceptive channels that lead to action, recognition and visual tours that promote different behaviors (Sanz, 1993). In the chromatic field this takes on foundation when colour is considered to serve different functions since it identifies and locates in space and time, describes the properties that define its character and possible uses and categorizes characteristics among other actions (Avila, 1996). In addition, cities are dynamic and as well as their inhabitants, they are changing organisms. Cities remain the same, become deteriorated, are renewed or go through transformations. Moreover, their environmental colour is the reflection of a single moment and can change with time according to the different variables that influence those changes. This unique and typical dynamics is the source of its polysemy and attraction.

Figure 2: Urban environmental colour of Nueva Córdoba neighbourhood.

With the aim of interpreting the urban environmental colour and verifying the colour perceived by the inhabitants of the city of Córdoba, a chromatic survey is carried out using the NCS. On the other hand, work is developed on some chosen study fields with observations, interviews and questionnaires to permanent or occasional inhabitants.

The purpose is to relate the physical-spatial context with the temporary-historical one which are considered essential in the experience and sense of place of the urban space and confirm the influence of colour on the urban experience and city identity.

Method of the chromatic survey

The environmental colour, as a psycho-physical phenomenon, is perceived together with other variables such as textures, chromatic contrasts, cesias, the material nature and aspect of limits, the position of the observer and the manner and speed of movement among others.

After recognizing paradigmatic urban places in the city of Cordoba, the environmental colour is verified in order to determine the colour palette that defines it.

The steps to follow for the chromatic survey are:

- the study fields are chosen, considering a priori those in which it is possible to read and interpret the environmental colour and relate it to the urban experience and the sense of place
- colour is measured using The Natural Colour System (NCS), which has already been used in previous works, to reveal the different hues and shades that shape the urban spaces.
- the chromatic survey is conducted at different times of the day and in different seasons.
- a synthesis matrix is laid out to present the readings of different variables of the physical-spatial context.
- chromatic palettes that define the urban environmental colour are devised.

Record to interpret the interaction between colour and chromatic-spatial experience

The original function of colours is to represent concepts so as to establish a communicative relationship between the individual and the physical environment. As a consequence, the chromatic experience depends on the quantitative and qualitative interaction of the different components and contexts that take part in it.

Some observations, questionnaires and interviews are carried out to confirm the relationships between environmental colour and experience, sense and identity. These actions are aimed at recording the associations, interpretations and meanings inhabitants confer to their chromatic perception by means of the urban spatial experience.

The purpose is to confirm that environmental colour encourages the experience, fosters the sense of place and stimulates enjoyable atmospheres for the people who perceive and inhabit those environments.

The steps to interpret the interaction between colour and urban chromatic experience are as follows:

- an interpretative observation is carried out with the aim of determining the behaviour and appropriations in the different selected testing environments. This observation takes place at different times of the day, on different week days and different seasons.

- with the aim of completing the analysis, questions are made to casual users to verify the association and the meaning the inhabitant relates to the perception of chromatic elements influencing public spaces.

- A synthesis matrix is laid out to present the results.

CONCLUSION

Environmental colour can be defined as the reading of predominant hues and shades that tinge the environment with certain colour. In addition, the perception of the chromatic expression of a city does not only depend on the physical-spatial context but it is also influenced by the emotional and cultural condition of the person who perceives it and by the historical-cultural context.

The environmental colour as the reading of predominant hues and shades that are perceived depending on the appearance and material nature of limits is an essential element in the urban experience, recalling atmospheres that encourage ways to inhabit and relate to the space.

The interventions in the city with emphasis on the chromatic aspect contribute with criteria for the building of urban spaces that prompt the experience of the city, essential for its identity, design and construction.

The performance of environmental colour with its iconic-linguistic potential is essential since it increases its capacity to inform, suggest and develop synaesthetic associations and create environments bringing about the experience of the city and the promotion of urban life which are vital for its identity, design and construction.

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colour & human comfort

Personalised Colour Palettes for Home Furnishing

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ABSTRACT

This study aimed to investigate how home furnishing stores can provide a *personalised colour palette* to its consumers in the United Kingdom. A framework of research methods was designed to support the exploratory nature of the study by conducting: a *Consumer Survey*, a *Designer Questionnaire*, and a *Colour Experiment*, which involved creating Virtual Reality (VR) panoramic High-definition (HD) living room designs based on a personalised colour palette for each experiment participant.

Large-scale surveys were recommended due to findings like: colour high impact on purchase decision, positive emotions associated with colours, possible gap between consumers' and designers' views on colour, and minimal consumer involvement in the colour palette creation process. The VR imaging was found a powerful tool that can increase the consumers' realization of preferred colours in addition to providing a colour preference database for home furnishing stores/designers. Further studying of the VR implementation strategies were recommended.

Keywords: *colour, interior design, colour preference, home furnishing, virtual reality*

INTRODUCTION

Colour is vital. Certain colours are of a symbolic meaning; therefore, colour is considered an individual experience (Manav, 2017). Scientists investigated the influence of interiors' colours on individuals perhaps because interiors dominate humans' perception and knowledge. Humans spend most of their lifetime in enclosed environments (*Kwallek* et al., 1997). Since colours reflect a personal expression and homes define one-self (Belk, 1988); it is essential to facilitate a variety of interiors' colours. During shopping price has a great impact; yet, colour is a great motivator.

In the design process, inspiration sources (i.e. nature, archives, art, etc.) are important as these: define the context, generate ideas, and evoke designer's mental abilities (Eckert and Stacey, 2000). Additionally, designer's understanding of aesthetics and design elements is essential

(Wilson, 2001). Although colour is a primary design element, some interior designers underestimate it and rely on ready-made sets/catalogues for colour decisions (Smith, 2003).

Interior designers widely use Computer Aided Design (i.e. *AutoCAD*) for modeling but recently more online tools are available for consumers' use too. Although simulation was applied in interiors research, it is not applied in stores. *IKEA* and *Decorilla* are examples of companies which offer Virtual Reality (VR) experience to the consumer (IKEA, 2013; Decorilla, 2017).

In consumer's mind, the significance of a customised product is higher than the physical product itself (Du Plessis and Rousseau, 2003); hence, this study was influenced by the importance of colours in home furnishing and the noticeable lack of colour personalisation.

MATERIALS AND METHODS

The design of methods and experimental work targeted achieving the aim of the study which is to investigate how home furnishing stores can provide a personalised colour palette to consumers in the United Kingdom (UK). Besides the literature review, the objectives explored: designers' approaches for palettes creation, consumers purchase attitudes including colours impact, colours availability in stores, and the use of VR technology to facilitate personalised colours.

A *Consumer Survey* (CS), a *Designer Questionnaire* (DQ), and a *Colour Experiment* including *Colour Experiment Feedback* (CEF) were conducted to address the research aim, objectives, and the *Research Questions.* A framework diagram was designed as illustrated in Figure 1. The core methodology design which consisted of four main stages: design, data collection, results, and analysis formed the CS and DQ while the CEF stemmed from the CS data as seen in the figure.

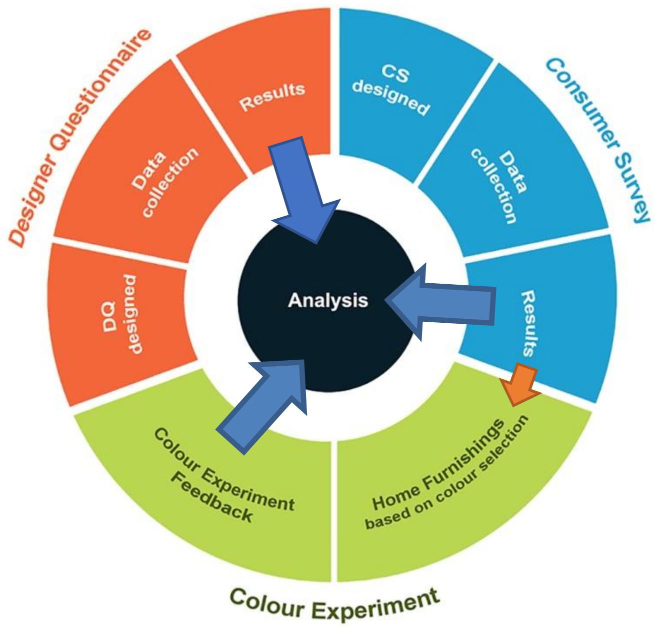

Figure 1: Methods and experimental framework diagram.

The *Research Questions* (RQ1 to RQ5) were as follows: RQ1: What are designers and consumers' views about the colours available in home furnishing stores? RQ2: How does colour influence the consumer's purchase decision and life quality? RQ3: What are the purchase attitudes of consumers in terms of frequency, motives, preferences, desire to shop, and store loyalty? RQ4:

How do consumers see the VR imaging as a tool for home furnishing shopping? RQ5: How does the consumer influence the colour palette process?

This study adopted both qualitative and quantitative approaches especially that the qualitative approach is suitable for dealing with subjective assessment of opinions (Kothari, 2004). The study did not target building/testing theories; therefore, *Content Analysis* was applied by classifying, summarising, and comparing. As illustrated in Figure 2, responses were split into phrases (*Quote*), then summarised in (*Subtheme*), and compared leading to final (Theme) (Schulz, 2012). Additionally, *Word Cloud* was another tool used for qualitative data visualization.

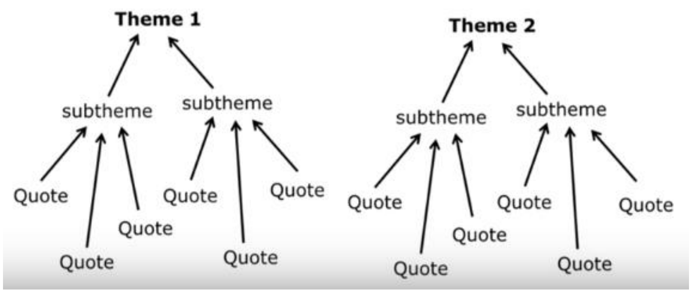

Figure 2: Coding and classification (Schulz, 2012).

CS sample determination was based on the statistical reports of *Office of National Statistics* (ONS, 2016) and *Snowball* sampling strategy was adopted. 29 UK-based consumers of age group 30-64 were involved in the survey which included closed-end questions of Likert scale or multiple-choice (70% of total questions) and open-end questions (30% of total questions). The survey questions explored consumer's purchase behaviours, colour impact on purchase, post-purchase experience, and participant's current living room satisfaction. Additionally, each participant selected 3 preferred colours from a colour wheel. Selected colours were later used to design the *Colour Experiment* simulation. For survey conducting and circulating, *Google Forms* and social media platforms were used (i.e. Facebook and Twitter).

Five participants were involved in the DQ which targeted designers who are aware of the home furnishing colour palette process. A set of predetermined questions were addressed to participants either by interviewing or form filling (as per participant's preference). Questions formed the DQ sections which investigated designer's inspiration sources, the palette creation process and its influencing factors, and the designer's information related to market analysis.

EXPERIMENTAL

The *Colour Experiment* relied on constructing 3-dimentional (3D) photo realistic panoramic high-definition (HD) images of customised living rooms based on participants' colour preferences. Due to time limitation the experiment was conducted with 6 participants based on availability and location. *Roomstyler* online platform was used to design the living rooms and generate the VR simulation. Figure 3 represents a panoramic equirectangular projection of living room P3 (P3 is the participant's code). Preferred colours were specified by Hue, Saturation, and Brightness values (HSB) using *Adobe Photoshop CC* and consequently, designs were based on these values. Walls and floorings were of less saturated hues and patterns were avoided. Living rooms VR panoramas were viewed on *Roomstyler* website using a smartphone placed inside a VR head-set (*Thumbs Up Immerse*). The CEF consisted of 8 pre-determined questions which explored: the participant's impression and satisfaction rating of provided colour personalisation and VR simulation, reasons of participant's current home colour choices (living room specifically), acceptance of VR if available in stores, and the influence of VR service price if provided in stores.

Figure 3: Equirectangular projection of living room P3.

RESULTS AND DISCUSSION

Using different tools for the DQ data gathering caused additional data sorting and non-response bias while using only *Google Forms* in the CS was effective. The use of social media platforms to circulate the CS did not facilitate calculating the survey response rate, however, the DQ response rate was determined and noticeably low (38%). Successful VR imaging was achieved by *Roomstyler* but the platform lacked colour readings and therefore, *Adobe Photoshop CC* tools were used.

Females were the major participants in the CS (79% of total participants) which supports what Silverstein and Sayre (2009) stated; that 94% of home furnishing purchase decisions are made by women. 96% of the CS participants were enthusiastic about colours and rated its influence on home furnishing shopping as *'Above 80%'.* Participants provided variable reasons behind the colour influence during shopping such as the colour effect on mood or selecting colours which fit in existing rooms. CS participants strongly agreed that furnishings' colours help in relaxation and can improve life quality. Additionally, participants were uncertain that their preferred colours are available in stores and this may reflect a confusion or unawareness. Price was found a major factor contributing to stores preferencing. Additionally, CS results show that final purchase decision is mostly made in stores. Although the survey did not indicate frequent shopping of furnishings, 45% of the participants indicated the possibility of impulse buying.

Unlike the consumers views provided in the CS, the DQ implied that designers see colour choices in furnishing stores are adequate for consumers. Some designers described consumers colour satisfaction with '*Neutral*' while others selected *'Satisfied'*. Designers acknowledged that consumers' influence on colour palette is minimal to none. DQ results indicated that colour palettes are highly influenced by the designer's awareness of: production process, colour combinations, and brand identity. Additionally, design aim or context and materials/process limitations may be prioritised. According to the DQ, the colour personalisation concept does not appear to be a common practice in stores and limited to bespoke interiors.

In the *Colour Experiment* and CEF, participants highly rated the rooms' simulations as a representation of their *'Personalised Colour Palette'* excpet for one participant who highlighted the importance of colour proportion. Participants explained some factors which affected their current living room furnishing colour choices such as: unavailability of certain colours in stores, selecting colours to fit previously owned items, and compromise with partners. All the participants highly accepted the VR experience and strongly agreed to its use in stores if available. The graphical representation using *Word Cloud* in Figure 4, shows the frequency of words addressed by the CEF participants to express the first impression about the personalised rooms simulation. High frequency of adjectives such as: like, light, calm, exciting, and pleasing indicate the positive impressions. Furthermore, CEF results implied that using VR tools in stores may depend on fees associated and assistance provided.

Figure 4: Colour Experiment Feedback, VR impression.

CONCLUSION

The methods and tools used in this study provided adequate results to support its aim and objectives. The study provided an overall idea about consumers and designers views on colours of home furnishing which highlighted a noticeable gap between both views such as colours avaliability and satisfaction. Colour choices limitation, which can negatively affect the market, may be caused by this gap in views in addition to the minimal consumer involvement in the colour decision process (as per the DQ results).

Since the DQ response rate was low and the designers' input was highly variable, a large-scale questionnaire is recommended. On the contrary, the CS can be a useful pilot for designing future statistical studies which give accurate representation of furnishing consumers in the UK.

Aligning with previous empirical work, this study showed that the colour palette decisions mainly rely on the designer's expertise which urges to investigate the designer's own colour preference influence on the palette outcome.

Achieving a '*personalised colour palette'* concept at the design stage currently appears uneasy because the palette process and designers' practices are variable and not specfically identified. However, the VR technology can be an alternative approach for personalisation. The recommendation of VR for palettes personalisation is based on the positive impressions expressed by the experiment participants in addition to the consumers tendency to make the final purchase decision in stores. Being a powerful tool, the VR may positively affect the purchase decision confidence and raise the consumers' realisation of their personal colour preferences.

Furthermore, providing VR tools in stores can generate a database of consumers' preferences and accordingly improve the understanding of consumers needs besides facilitating consumer targeting. Price is the factor that may limit the use of VR in home furnishing stores; hence, a detailed study of implementation possibilities is highly required.

In the field of home furnishing, it is important to understand that colour is not only a marketing tool to solely drive the sales but also essential to the consumer's self-expression, life quality, and wellbeing.

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Colour and Spatial Comfort in Architectural Context

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ABSTRACT
In architecture, colour has both subjective and objective attributes within its multifaceted nature. Although colour is light, human response to colour is a subjective experience and implies more complex relations and intricate ties when the term "comfort" is comprehended within the architectural context. This paper tends to explore human comfort as a matter of spatial quality within architectural colour design. The aim of the study is to uncover meanings attributed to spatial comfort and to investigate predictors of colour design characteristics in this aspect. The results indicate that pleasantness, harmony and spaciousness are determinative over comfort. Function is observed as another determinant for colour design criteria and evaluation of spatial comfort. In terms of colour and scheme characteristics; light values, warm hues, weak chromas and similar colour relations for hue and chroma are found more appropriate for a comfortable space.

Keywords: *architectural colour, spatial comfort, spaciousness, pleasantness, colour harmony*

INTRODUCTION
Comfort (or being *comfortable*) is a sense of physical or psychological ease, often characterized as a lack of hardship. Comfort is taken under basic needs of human in Maslow's Hierarchy of Needs and interpreted as a part of physiological accommodation (Johnson, 1994). Architecture used to study comfort under building physics. From this point of view, a built environment should provide a level of visual comfort like the other physical requirements. Such requirements lead visual comfort to some lighting standards based on quantitative references, described on task surfaces. With this understanding, colour of a surface is taken into consideration by its reflectance. Although colour is light, human response to colour is a subjective experience and implies more complex relations and intricate ties when the term "comfort" is comprised within the architectural

context. Rival colour theories of philosophy and science use to stress colour either in object or subject based frames parallel to their views. Sustaining their guidance, contribution and indemnity, it can be argued that 'colour and human comfort' converges qualities of light, object properties and subjective experiences at the same time, within the architectural context (Ural, 2016).

Colour is not an isolated entity in architecture, it is always perceived together with the other elements of the visual environment. Theoretical knowledge about colour comes from several disciplines and arises from research mostly where colours are abstracted and simplified in to colour chips and samples. However, recent research in the field of design and architecture reveals the fact that the evaluations of contextual/applied colours and isolated/abstract colour chips are quite different (Ural, Yilmazer, 2010). Besides the physical context in which the colour is viewed, the psychological context is also needed to be examined.

In architecture, colour is not only a component of Vitruvius' Venustas, but it is also an element of his Utilitas. Some recent research show the effects of colour characteristics on occupants' productivity, self satisfaction, overall comfort, mood and their interrelation (Ural et.al., 2011, Öztürk et.al., 2012) As colour is a part of aesthetic judgement, the correspondence between harmony, pleasantness and comfort is also important (Ural, Yilmazer, 2010, Akbay, 2013).

EXPERIMENTAL STUDY

This paper bunches a set of studies carried out as a part of studio works of the elective course 'Colour Theory and Applications' given in Bilkent University, Department of Interior Architecture and Environmental Design, between the years 2015-2018. The studies realized by different student groups during the four semesters, were gathered as the two components of the paper; exploration of the meanings attributed to comfort and analysis of spatial colour combinations in relation of comfort in architectural context.

Exploration of the meanings attributed to comfort: For this study the bipolar adjectives/attitudes by Osgood et.al. (1957) and Akbay (2013), were examined and discussed by the student groups in two stages. Firstly, 69 adjectives were selected predicting their stronger attributes to architectural space (a total of 54 students, in 24 groups). Then, this list was narrowed down 27 adjectives to explore their relation to spatial comfort in architectural context (a total of 42 students, in 20 groups). Finally ,a group of 30 students were asked to evaluate *comfort* against the adjective pairs, by using five-point rating scales, ranging from -2 to +2.

Analysis of spatial colour combinations: In order to observe the effects of colour and colour scheme characteristics on evaluation of spatial comfort, students were asked to create colour compositions for a five meters by five meters interior space, with three meters of height. During the discussions before starting the studio work, students arrived at a consensus that the functional context might be a determinative factor for their colour design decisions. So that colour design problem was redefined for two different functions; living and working. A total of 16 colour compositions (eight for living and eight for working layouts) were selected to be evaluated. The compositions were transferred to simplified 3D digital models and the images (Fig. 1) were evaluated against five-point rating scales, ranging from -2 to +2.

Four concepts/ constructs -*spaciousness, pleasantness, harmony* and *comfort*- were intended for this analysis, as they were accounted for the biggest factor for evaluating architectural/ spatial context, by previous research (Ural and Yilmazer, 2010). Scheme characteristics were defined as similar, moderate or contrasting for three of the colour dimensions (hue, value, chroma). For the cases defined as *similar*, the dominant descriptive stated as; *warm* or *cold* for hue, *light* or *dark* for value and *weak* or *strong* for chroma. For the cases defined as *contrasting* or *moderate* the descriptive stated as *both* for data analysis. The data were statistically computed by SPSS 12.

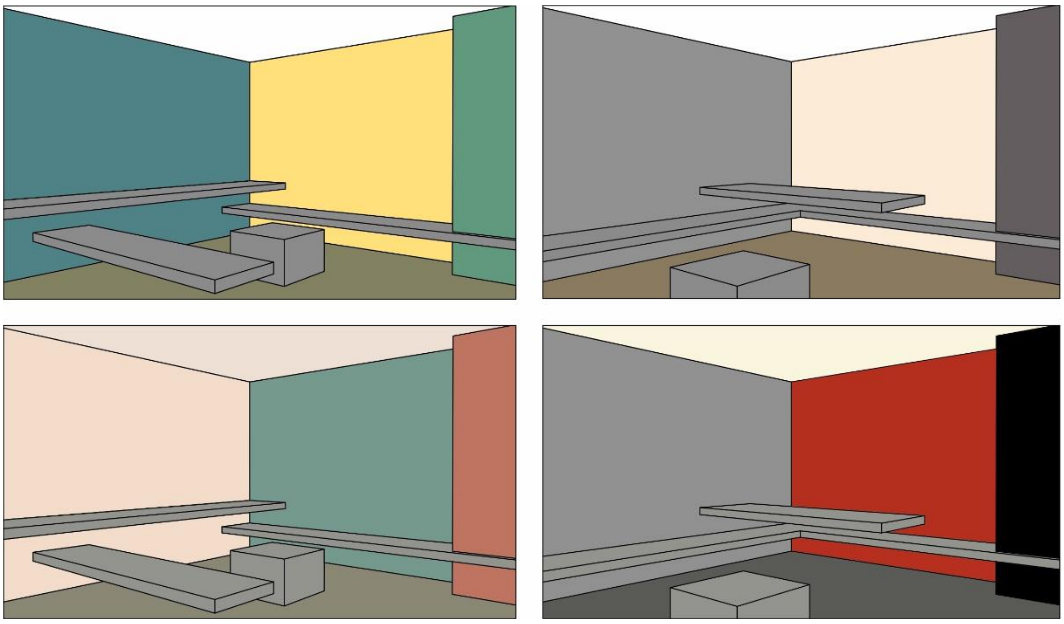

Figure 1: Colour composition examples for living (left) and working (right) layouts.

RESULTS AND DISCUSSION

The meanings attributed to spatial/architectural comfort were analysed by the mean values and factor analysis. The highest absolute mean value was observed for *pleasant* (*M*=1.88, *SD*=0.35) and followed by *positive* (*M*=1.75, *SD*=1.33), *spacious* (*M*=1.67, *SD*=0.74), *harmonious* (*M*=1.58, *SD*=0.80), *interesting* (*M*=1.55, *SD*=0.76) and *good* (*M*=1.53, *SD*=0.53). These adjectives can be considered as the key meanings attributed to comfort in architectural/ spatial context. The lowest absolute mean value was seen for the adjective pair *colourful – colourless* (*M*=0.01, *SD*=1.07). So that none of the polar adjectives were pointed. In other words, whether being colourful or colourless is determinative over *comfort*, has not been elicited by this evaluation. The adjectives *hot - cold* (*M*=0.03, *SD*=0.92), *light – dark* (*M*=0.07, *SD*=0.83), *active – passive* (*M*=0.08, *SD*=1.35) and *static - dynamic* (*M*=0.02, *SD*=1.15) also showed low mean values.

In order to see which adjective pairs go together, factor analysis was performed. Table 1 shows the categorized adjectives under extracted factors and variance percentages accounted for the factors. The underlined adjectives show the positive meaning attributed to *comfort*. By factor analysis six factors were extracted. The first factor accounted for 20.2% and the second factor accounted for 19.5%. The first factor seems to be *emotion* and the second gathers *physical* and *connotation* types of response attitudes, as listed by Akbay (2013). The other factors show a categorization of all types of response attitudes.

To see the associations between spaciousness, pleasantness, harmony and comfort, the data analysed by correlations. The findings indicate strong significant positive relationships among all constructs.

Table 1: The orthogonal factor loading matrices for 27 adjectives.

factor 1	factor 2	factor 3
pleasurable – painful[m] active – passive[e] pleasant – unpleasant[e] static – dynamic[e] light – dark[p] extroverted – introverted[e] positive - negative [e] 20.2%*	simple – complex[p] public – private[c] constrained – free[c] harmonious - dissonant[p] 19.5%*	meaningful – meaningless[e] hot – cold[p] good – bad[e] vivid – pale[p] complete - incomplete[e] 15.5%*
factor 4	**factor 5**	**factor 6**
heterogeneous – homogeneous[p] exciting – calming[e] confined – spacious[e] 13.5%*	unusual – usual[m] colourful – colourless[p] natural – artificial[c] 13.2%*	interesting – boring[e] stable – changeable[e] beautiful – ugly[c] dense - sparce[e] hard – soft[c] 13.0%*

* variance percentages accounted for the factors
[c] connotation; [e] emotion; [m] meaning; [p] physical type of response attitude (Akbay, 2013)

In order to observe the effects of colour combinations on evaluation of spatial comfort, regression analysis was performed. In the first analysis in which all the data analysed, *function* observed as second predictor and explained 23% of the variance in comfort evaluations. Then the data reanalysed separately for living and working layouts. Table 2 shows the predictors of colour and scheme characteristics for living and working layouts.

Results showed that different colour and scheme characteristics are determinative over *comfort* ratings when *function* changes. Value of colours was entered first and explained 55% of the variance in spatial comfort, while hue of colours was entered second (23%) for living space. Light values and warm hues rated with higher scores. However, for working layout chroma scheme and chroma entered first to and explained a total of 72% of the variance in spatial comfort. Comfort associated with similar chroma schemes and weak chroma colours. These predictors followed by hue scheme and hue explaining a further total of 26%. Similarity of hue schemes and warm hues were found more comfortable.

Table 2: Stepwise multiple regression of colour and scheme characteristics over *comfort.*

Function: living			Function: working		
variable	*R* sq change	Sig.	variable	*R* sq change	Sig.
V	0.55	.000	schC	0.42	.000
H	0.23	.000	C	0.30	.000
			schH	0.22	.000
			H	0.04	.001

Colour characteristics; hue:H, value:V, chroma:C
Scheme cahacteristics; schH: similarity/ contrast in hue, schV: similarity/ contrast in value, schC: similarity/ contrast in chroma

CONCLUSION

This paper tends to explore human comfort as a matter of spatial quality within architectural colour design. Functional requirement, spatial perception and aesthetic judgement are seen integral parts of colour design criteria. So that the aim of the study is to uncover meanings attributed to spatial comfort and to investigate predictors of colour design characteristics in this aspect.

From the findings it can be concluded that pleasantness, harmony and spaciousness are determinative over comfort. However, meanings attributed to comfort are not limited to these constructs, and the factors/ categories of meanings have more intricate interrelations. Function is observed as another determinant for colour design criteria and evaluation of spatial comfort. Colour and scheme characteristics are seen dependent on function, for evaluation of an architectural space. Nevertheless, it can be said that weak chroma, light value and warm colours are found more appropriate for a comfortable space. Harmony of similarities in hue schemes (monochromatic and analogous colour schemes) and similar chroma relations are preferred over contrasts.

The results presented here are limited within the scope of this paper. Further studies, particularly in full scale experimental setups, will reveal a better understanding of the relations between colour and human comfort.

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Investigating Colour Task Performance for Occupants' Comfort in Office Environment

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ABSTRACT

Aim of this paper is to explore the effects of different colour temperatures on colour based task performance upon colour differentiation performances. For this purpose, three attributes of colour were the focused in the colour differentiation task. A two-dimensional colour differentiation model (ColDM) was designed based on Munsell 100 Hue Test and it was developed regarding the choma and value attributes. The study was conducted with 100 participants, in a full-scale office set-up under two different light colour temperature; 2700K and 4000K. The results showed that there was a significant difference between chroma differentiation performances of red, green, yellow hues; hue differentiation performances of red-yellow, green-blue, and blue-purple intervals in terms of accuracy. In terms of self- satisfaction, results showed that participants significantly worked more comfortable under 4000K compared to 2700K and there was a direct relationship between self- satisfaction and task performance. When office environment is assured of comfort, performance can be maintained at high levels.

Keywords: *Comfort in Office Environment, Colour Differentiation Task, Task Performance, Colour Temperature, Office Environment*

INTRODUCTION

Quality of work life is highly related to personal comfort. When workspace quality assures comfort, work performance has maintained at high levels. Also, visual comfort is the most important factor on mood in office environment. In order to supply comfort for work-related tasks, there should be appropriate lighting conditions; higher CCT conditions facilitate better work performance compared to lower ones (Steffy, 2002).

Manav (2007), found that among variety of CCTs; for the impression of spaciousness and comfort 4000K was preferred. For relaxation and saturation evaluations 2700K was preferred. Another research by Izsó et al. (2009) was compatible with Manav's study in terms of relaxation. It found that the combination of low CCT (2700K) and low illuminance level (100lux) created relaxing environment compared to the combination of high CCT (4000K) and high illumination level (1300lux). Also, Park et al. (2010) stated that in the office environment, 4000K is the most preferred colour temperature and work performance is better under the 4000K compared to other colour temperatures. Likewise the work performance, participants have more positive mood under higher colour temperatures; they are more alive, concentrative, and tensioned and less sleepy, tedious, and undesirable compared to lower colour temperatures.

The study, conducted by Shamsul et al. (2013) found that in terms of typing performances (performance refers to the speed and accuracy of processing visual information), subjects performed significantly better under 4000K and 6200K colour temperatures than 2700K colour temperature in terms of speed of task. Besides, less typing errors were made under 6200K and followed by 4000K colour temperature. It was stated that 4000K and 6200K lightings were more beneficial for computer-based tasks in office environments. Sivaji et al. (2013), found that although visual comfort level and preferences were significantly higher under the 4000K light; computer-based typing task performances were not significantly differed among 2700K, 4000K, and 6200K colour temperatures.

Although there are numerous experimental studies based on lighting conditions and task performance, there is no sufficient research regarding the effects of colour temperature on work performance of people whose instruments are colour oriented tasks in the office environment. The main purpose of this study is to investigating colour task performance for occupants' comfort in office environment.

METHODOLOGY

1. EXPERIMENTAL SET-UP

The study was conducted in a full-scale experiment room at the department of Interior Architecture and Environmental Design at Bilkent University. The experiment room was set up as a real office room. The dimensions of the room were 4.00 m length, 4.10 m wide and 3.20 m height. To control the effects of artificial light on the performance of workers, daylight penetration to the room was prevented with black light-tight windows. To control/minimize the effect of visual ambience on the task performance, achromatic colour scheme was applied by painting all of the wall surfaces with gray colour; using neutral gray fabric coverings on the furnishing and the floor (Figure 1). The colour task performance test was conducted on 40 degrees inclined setup to establish an offending zone for reflection with the 40-degree sitting line of sight and 60-degree cone of vision. The experiment was conducted under two lighting set-ups; four OSRAM fluorescent lamps LUMILUX T8 36W/827 (2700K warm white light) and four OSRAM fluorescent lamps LUMILUX T8 36W/840 (4000K cold white light). Both of the lighting equipment had the same luminous flux; 3100 Lm. The average illuminance value for 4000K recorded 426 lux and for 2700K was 424 lux. The SPD of fluorescent lamp are also similar and their CRI levels are in the good colour rendering group: 1B (Ra: 80…89) (Kürkçü, 2017).

Figure 1: Office Set-up under 4000K (left side) and 2700K (right side) Fluorescent Lighting

2. SAMPLE GROUP

The sample group was completed the basic colour education chosen from Department of Interior Architecture and Environmental Design at Bilkent University, Ankara, Turkey. The ratio of female student to male student at the department was three to one. Regarding to the ratio, 73 females and 27 males participated in the experiment. The mean age of participants was 23,14 ranging from 19 to 31 years.

3. DATA COLLECTION AND ANALYSIS

In the experiment the same participant group was repeatedly tested. Participants were divided randomly into two groups; half of the participants, between 1 to 50 participants, completed the colour task performance at 2700K for the first time and at least one-week period carried out the same colour task at 4000K lighting setup. The other half, between 51 to 100 participants, completed the colour task performance in reverse order. Participants carried out the task performance one by one and ColDM (colour differentiation model)(Figure 2) took almost 45 minutes for each participant. The experimental study consists of two parts; ColDM and questionnaires. Questionnaire comprises of Watson's mood measurement test Positive Affect Negative Affect Schedule (PANAS), self- satisfaction test by Office Lighting Survey (OLS) and perceived performance test.

In this study; speed of task which refers to time spent for completing each colour task and accuracy of task which refers to arranging the colour chips in correct order with the fewest errors were investigated.

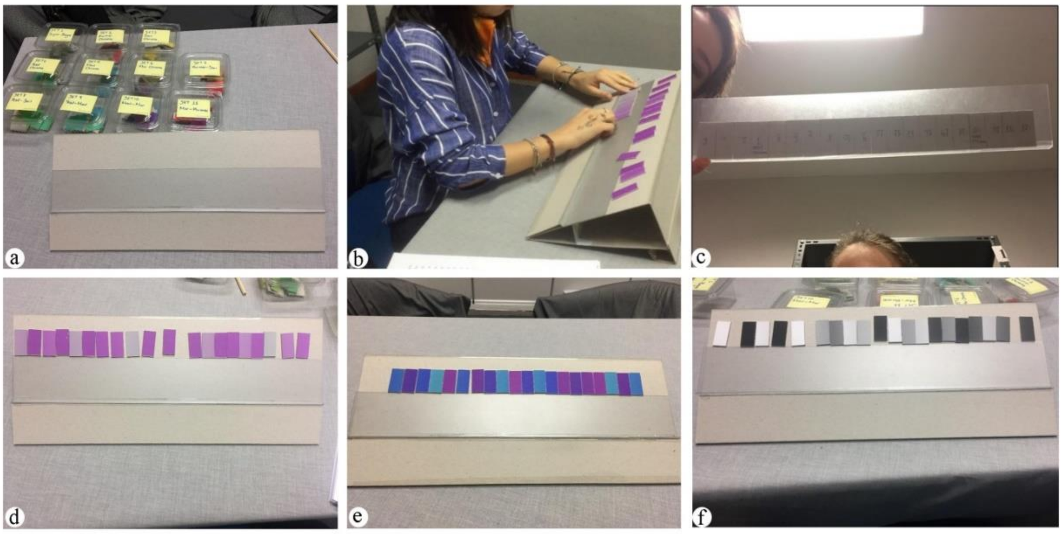

Figure 2: Application of ColDM (a; experiment setup, b; a view from ColDM implementation, c; ColDM answer checking, d; purple chroma differentiation task, e; blue-purple hue differentiation task, f; value differentiation task).

RESULTS AND DISCUSSION

		4000K		2700K		Wilcoxon	
		Mean	SD	Mean	SD	*z*	*p*
Red Chroma	Accuracy	19,02	1,341	18,56	1,69	-2,188	**0,029**
	Speed(time spent)	53,67	21,402	53,11	15,906	-,419	0,675
Green Chroma	Accuracy	16,68	2,155	14,79	2,938	-4,810	**0,000**
	Speed(time spent)	68,32	27,162	65,61	19,652	-,169	0,866
Blue Chroma	Accuracy	16,09	2,375	15,55	2,79	-1,947	0,052
	Speed(time spent)	69,21	25,014	67,87	22,847	-1,020	0,308
Yellow Chroma	Accuracy	17,11	1,999	16,14	2,474	-3,180	**0,001**
	Speed(time spent)	59,16	21,22	57,68	17,355	-,742	0,458
Purple Chroma	Accuracy	12,72	2,005	12,19	2,083	-1,646	0,100
	Speed(time spent)	63,14	39,428	65,14	26,052	-2,004	**0,045**
Red-Yellow Hue	Accuracy	17,84	1,916	16,85	2,181	-3,652	**0,000**
	Speed(time spent)	60,44	23,889	57,46	18,61	-1,197	0,231
Yellow-Green Hue	Accuracy	18,97	1,553	18,66	1,865	-1,760	0,078
	Speed(time spent)	57,79	21,647	56,9	19,409	-,029	0,977
Green-Blue Hue	Accuracy	17,18	2,855	15,48	3,489	-4,310	**0,000**
	Speed(time spent)	69,76	25,975	67,1	24,632	-,772	0,44
Blue-Purple Hue	Accuracy	18,9	1,474	18,3	2,298	-2,214	**0,027**
	Speed(time spent)	65,94	28,167	63,71	28,302	-1,515	0,130
Purple-Red Hue	Accuracy	18,2	1,959	17,64	3,249	-1,368	0,171
	Speed(time spent)	65,12	26,342	64,16	24,73	-,048	0,962
Value	Accuracy	18,5	1,352	18,79	1,585	-1,898	0,058
	Speed(time spent)	48,96	18,232	47,47	15,516	-,698	0,485

Table 1: Statistical Comparison of Accuracy and Speed of Colour Task Performances

The results revealed that the accuracy of chroma differentiation performances of red, green, yellow; hue differentiation performances of red-yellow, green-blue, and blue-purple performances. Performances differ significantly under 2700K and 4000K while the speed of colour task performances have no significant difference under the mentioned colour temperatures (Table 1). Since task performance was evaluated as the combination of accuracy and speed of task, the results showed that participants' red, green, yellow, purple chroma differentiation performances and red-yellow, green-blue, blue-purple hue differentiation performances were better under 4000K than 2700K. However, blue chroma differentiation performance, green-yellow hue and purple- red hue differentiation performance and value differentiation performance did not show any significant change between 2700K and 4000K colour temperatures. The result of this study is associated with studies in the literature except the study conducted by Sivaji et al. (2013). When colour tasks are analyzed based on the attributes of colour, it was revealed that, total hue differentiation tasks performance (z=-6,232, p=,000) and chroma differentiation tasks performance (z=-6,426, p=,000) were significantly better under 4000K compared to 2700K colour temperature whereas there was no significant difference in value differentiation task between mentioned colour temperatures (z=-1,898, p=,058).

Moreover, this study explored the effects of colour temperatures on user's mood. When each PANAS items were compared before and after the exposure of light and task performance, the results showed that under 4000K colour temperature, there was significant decrease in distressed (p=,000), irritable (p=,000), ashamed (p=,025), nervous (p=,050), and afraid (p=,008) moods and significant increase in alert (p=,031), attentive (p=,000), and active (p=,008) moods. Under 2700K colour temperature, negative mood of distressed (p=,000), upset (p=,000), irritable (p=,011), nervous (p=,014), and jittery (p=,025) decreased significantly; while positive mood of excited (p=,018) increased significantly and determined (p=,010) decreased significantly. As a result, the change of positive mood under two colour temperatures showed 4000K affected participants' mood in a positive way since 4000K colour temperature aroused positive moods more than 2700K. The results of effects of different colour temperatures on mood compatible with previous studies; a study, conducted by Park et al., (2010) stated that under higher colour temperature conditions; participants were more alive, concentrative, and tensioned and less sleepy, tedious, and undesirable compared to lower colour temperature conditions. Similarly, Shamsul et al. (2013) found that subjective alertness level was significantly decreased under 2700K.

In terms of self- satisfaction, results showed that participants significantly worked more comfortable under 4000K compared to 2700K (p = 0,009) and there was a direct relationship between self- satisfaction and task performance. The satisfaction levels from the lighting of the office under 4000K and 2700K colour temperatures were significantly different (z=-4,162, p = 0,000). 4000K was preferred for working activity. The results of the study associated with previous studies stated that among a series of colour temperatures 4000K colour temperature is the most comfortable and preferred colour temperature for reading-based performance in office environment (Manav, 2007; Izsó et al., 2009; Park et al., 2010; Shamsul et al., 2013; Sivaji et al., 2013).

CONCLUSION

The effects of colour temperatures on colour task performance for occupants' comfort in office environment were investigated in full-scale experimental office environment under 2700K and 4000K colour temperatures. In order to measure the performance, a colour task implementation method was used. The results of the study explored that colour temperatures affect colour task performance significantly in terms of accuracy of task. 4000K lighting enables users to differentiate hue and chroma attributes of colour better significantly than 2700K colour temperature. It was also found that 4000K generated more positive mood than 2700K colour temperature. After exposure to 4000K participants became more alert, attentive and active. Also, participants evaluated 4000K colour temperature as more comfortable than 2700K. The study also showed that there was a direct relationship between self- satisfaction, mood, and comfort and task performance.

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Beyond Supergraphics – a Review of the Usage of Saturated Colours in Contemporary Urban Environments

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ABSTRACT

This paper offers a brief review of the history of Supergraphics and its development in contemporary settings. With knowledge of the features and functions of Supergraphics and the variants, this paper argues that the perspective of Supergraphics is not accurate to understand and explain designs applying saturated colour on 'nonarchitectural' spaces with different emphases. By analysing the intentions, features and functions of applying saturated colours in selected urban design projects, this paper attempts to present the differences between urban designs characterised by saturated colours and Supergraphics. Thinking beyond the realm of Supergraphics allows us to have a better understanding of the relationship between saturated colour and urban environments, which will benefit the environmental colour design in the future.

Keywords: *Supergraphics, Saturated colours, Urban environments*

INTRODUCTION

Due to the historical, cultural and geographical reasons, the colour schemes of architectures in general are likely to be subtle and concordant. However, along with a culture movement during the 1960s, gigantic geometric patterns in bold colours were painted on architectures to add some spices to the invariable architectural colour palettes. This way of applying out of scale graphics on architecture is later defined as Supergraphics. Since then this graphic technique has been applied to different fields and act as an important resource to introduce saturated colours to urban environments. Meanwhile, more bright and bold colours start to appear in urban and landscape designs since the last decade. However, are all saturated colours in a large scale appearing in urban environments should be considered and evaluated as Supergraphics?

HISTORY OF SUPERGRAPHICS

The term 'Supergraphics' coined by C.Ray Smith originally referred to those geometric patterns with bold colours painted on the walls and have been in vogue throughout the late 60s and 70s.

Despite the ornamental features that Supergraphics may present at first impression, the initial purpose of this graphic technique was to 'produce an optical effect of expanding a space or volume' (Smith, 1977, p270). This way of applying pigmented colour on architectural surfaces was engaged as a tool for spatial experiments in the Supermannerism, a post-modern architecture movement. Although painted colour has deemed secondary to other active media of architecture, its capabilities of erasure were acknowledged by De Stijl and Le Corbusier and applied in both interior and exterior surfaces since the 1920s. McMorrough (2007, p65) proposed that the understanding of paint as a 'shortcut to transformation' that has the ability to 'remove solidity, gravity, and even history' provides a historical context and fertile ground for Supergraphics. Along with this movement, the role of colour has been reconsidered. Cesar Pelli argues that Supergraphics expand the range of architecture and 'colour in themselves can become architecture', which should be regarded as one more tool in many cases (Pelli, cited in McMorrough 2007).

Figure 1: Bathhouse Graphics, (McMorrough, 2007, p66)

This graphic technique that engages painting was firstly tested on the interior design of the Bathhouse at Sea Rach as an instant response to budget cuts (Figure 1). The gigantic geometric patterns with bright colours fulfil the intended design requirements and explore possibilities to extend the space (Smith, 1967, p133). This graphic device was later interpreted as a way to challenge the architectural spaces visually and conceptually by the optical effects that 'destroy architectural planes, distort corners and explode the rectangular boxes…' and the implication that the space and the volume of architectures continue with the graphics (Smith, 1967, p133). Supergraphics work on existing structures and seek changes in architectural experience by generating optical effects. Supermannerists consider it as a solution that was generated during the building process based on permitting conditions, which challenges the pre-set architecture design process. Soon after, this graphic device spread in both interior and exterior application due to its efficiency and feasibility as a tool for instant changes. With the development of this technique, Supergraphics were no longer limited to using identifiable elements such as stripes, circles and arrows but also included letters and numbers. The involvement of alphanumeric signs enhanced the signifying capabilities of Supergraphics and extended its function to new terrain including directional aids and definers of space (Smith, 1972).

Subsequently, Supergraphics were introduced to urban environments as a fast and cheap tool in urban renewal due to its capacities for reality-altering effects. Without the demolition and rebuilding of existing structures, Supergraphics covered the unsatisfying details of vacant urban spaces in a cheap and irreversible way and were believed to have positive psychological effects (McMorrough, 2007, p71-72). Those renewal projects were expanding in depressed areas of big cities in America, such as New York City, Boston and Chicago. Supergraphics were applied to conceal the boundaries between architectural surfaces, which implied a gesture of challenging the existing conditions. However, the intention of Supergraphics was expanded or later distorted along with the prevalence of this technique when it was simply used as a method of low-cost beautification and aesthetic improvement (Smith, 1970). Meanwhile, there seemed to be no specific intentions of colour decisions as long as the schemes look bright and good. The faddish use of Supergraphics as a purely decorative device was criticised by the pioneer of Supergraphics designer, Barbara Solomon, who urged that there should be a better reason to engage this device. The arbitrary use of Supergraphics both in form and concept made it less identifiable with other decorative devices in urban environments, for instance, murals, billboards and gigantic patterns on single walls. Some argued that this method is only a 'short-term strategy to give sex appeal to our environment', which cannot solve the actual social problems but to provide a visual relief (Smith, 1970, p106).

SUPERGRAPHICS IN CONTEMPORARY SETTINGS

With the shift of design trends, Supergraphics quickly fell out of fashion after reaching the peak during the 1970s. However, this graphic technique to architecture surfaces did not entirely subside and came back into sight in different variants with more clear functional emphases. López (2015, p150-151) deems that the term Environmental Graphics can be used to generalise different variants of Supergraphics in contemporary settings. However, this paper argues that there are two major branches that should be differentiated in both understandings and applications. Both of the approaches clarify reasons to engage this graphic device and develop it according to the purposes respectively. Environmental graphic design (EGD) focuses on the efficiency and accuracy of information communication between the environments and viewer. EGD refined the signage capacities of Supergraphics and use signs and colours to deliver aids in wayfinding and place identification (Calori and Vanden-Eynden, 2015). Different colours are associated with assigned categories and are selected to be as distinct from each other and other environmental colours as possible. Saturated and bright colours in various hues such as primary colours are applied to enhance the visibility and increase the chance to be memorised and identified. EGD is regarded as a cross-disciplinary field that includes graphic, architecture, industrial and relevant design disciplines, which is widely used in many indoor public spaces such as, airports, stadiums and metro stations. It maintains the strong association with architecture as the original Supergraphics but EGD reinforces the communication function with identifiable visual images, which has been extended to fields such as functional division and place-making (Calori and Vanden-Eynden, 2015).

A specific type of art installation that proliferates in both interior and exterior applications is regarded as another variant of Supergraphics in contemporary settings. Artists and designers applied pre-set patterns and colour schemes which are rooted in strong personal style to cover architecture or facilities surfaces to intervene the space. Instead of being grounded in the original intention of Supergraphics, most artists use the 'form' of Supergraphics as a way of exhibiting their artworks in order to achieve certain visual impact. Artists such as Morag Myerscough, Michael Li and Felice Varini employ this specific type of art installation as a way of intervention in urban public spaces (López, 2015). However, it is noticeable that although the giant abstract patterns and vibrant colours may achieve similar psychological effects and attract people as Supergraphics do, this approach addresses more on art itself than the interaction between graphics and architectures. Therefore, the process of making colour decisions seems to be detached from contexts and colour schemes are relatively fixed as a reinforcement for the personal art style. This variant of Supergraphics contains the function of branding artists themselves and their artworks, which leaves restricted flexibility for colour choices. Its function of branding and promotion is more clarified when artists collaborate with brands commercially.

Figure 2: Manhattan Flagship Store Facade and Window Displays on Fifth Avenue Go Polka Dots (Y.C., 2012).

Yayoi Kusama brought her famous polka dots to the Supergraphic on the storefront of Louis Vuitton in New York City indicating their further collaborations in designs. López (2015, p153) states that this commissioned art installation blurs the boundaries between art, Supergraphics and advertising. Although art installations presented in the format of Supergraphics have potentials to generate social effects, this approach has always been considered as a temporal stimulus in urban environments. In this case, saturated colours are applied mainly to serve the intentions of artworks, therefore, the subtle interaction between colours and environments becomes subordinate or ignored.

BEYOND SUPERGRAPHICS

Based on aforementioned examples, Supergraphics and its variants are still important resources for introducing saturated colours to current urban environments. However, this paper argues that not all designs applying saturated colour on a large area in urban environments should be understood and evaluated from the perspective of Supergraphics despite the similarity in visual impression. Over the last decade, there are emerging phenomena that urban design projects employ saturated colours as a distinct design element. Although these projects inherit some features and functions from Supergraphics, they are different in intentions, emphases and therefore the effects. This paper will illustrate this argument from the following perspectives:

a. Design intention and colour decisions

In these design projects, saturated colours applied on surfaces are no longer used as a way to challenge the existing structure of architecture. Many of the cases are found in 'nonarchitectural' open spaces, such as parks, streets, plazas or underpasses. The focus of the design is about the place itself instead of the interaction with architectures. Take the example of Garscube Landscape Link in Glasgow, the vibrant red is introduced as a permanent component to the environment. The intention is to use the bright colour to enlarge the space, create a friendly atmosphere and give this space a strong identity as a way to claim this territory for pedestrians and cyclists, while working as a signifier of the regional regeneration. Embedded as a part of urban design, the colour decisions are more likely to be tailored to the specific context rather than being predetermined in artworks or graphic designs. With a clear emphasis on urban dynamic and social changes, the colour palettes have further connections with local culture and society. Located in the red light district in Paris, the colour scheme in Pigalle basketball court tries to tell a different story on behalf of the young generation. The designer Stephane Ashpool together with Ill-Studio generates this new design as a way to 'explore the relationship between sport, art and culture' and function as a 'powerful socio-cultural indicator' (Macnair, 2017). The colour palette is strongly associated with basketball and Parisian culture, which can provide a resonance for local teenagers. Being immersed in the place created by the bright and artistic colours, users of the court are able to escape from the unsatisfying urban surroundings and enjoy the sport.

Figure 3: A front view of Pigalle basketball court (Yu, 2017).

b. Features and functions

The function of coverage is one of the most important attributes of Supergraphics (McMorrough, 2007). This technique has been referred to and applied in urban design. Instead of aiming to conceal architectural surfaces, saturated colours are used to 'cover' the complexity and unwanted details of urban environments and redirect the focus of the place. However, there are some features different from Supergraphics in this new approach needed to be identified. Firstly, the way of viewing and experiencing the environments shifts due to the location of visual stimuli. Supergraphics as a tool in urban renewal have always been applied to walls and sometimes been mixed with murals. People were expected to view the images from a distance, which also suggests a psychological distance between the object and audiences. In some urban design projects, colours are applied on the pavements and surfaces in relatively closed space to allow people to immerse in the designed environment. Therefore, the colour becomes a key element of creating a sense of place where the decorative function is deemed secondary. Secondly, as being considered as an intergraded part of a design, colours are presented with certain materials to provide the intended sensual experience rather than being used as an additional makeup. Studio Fink transferred a concrete courtyard of an Italian art museum to a temporary landscape as a place for socialising during the period of an art exhibition (Howarth, 2015). The ground surface was covered with coloured AstroTurf. The combination of tactile and visual changes encourages people to use and interact with space, where used to be described as bleak and unforgiving. In addition, the media for colour are also selected based on the functional requirements of the place. A special rubber is used to reduce the chance of injury and noises during the game in the Pigalle basketball court (Morby, 2015).

Last but not the least, graphic technique in urban design is not the sole attraction but an active actor that coordinates with other design elements in urban design. Saturated colours may attract people's attention at the first place, however, the public space is supposed to facilitate various activities in order to maintain the aliveness. Different shades of red and pink are applied in the Superkilen Park in Copenhagen in geometric patterns. In addition to endowing a strong identity and functioning as a way of decoration, the colours and patterns indicate the functional division of the space, for instance, parking space, cycling path and playground. However, with the prevalence of mobile devices and social media, a strong identifiable colour itself can trigger activities in the urban environments, for example, the Instagram phenomenon-Paul Smith's Pink wall (Mau, 2017).

CONCLUSION

By analysing the above cases, this paper attempts to identify the differences between Supergraphics and urban designs that engage saturated colours. The cases suggest that saturated colours have great potentials in urban environments as an integrated part of urban design. Although the influence on the openness to bold colours and the graphical way of applying them can be traced back to Supergraphics, the intentions of using saturated colour, the process of making colour decisions and the role colour plays are modified in urban design projects. The focus shifts from the interaction between graphic and architecture to the place itself. Colours as a design component are used more restrained to serve intended purposes rather than being a purely decorative element.

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Colour and Human Comfort in Innovative Schools. The Negrar Study Case

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ABSTRACT

In 2016 the Italian Ministry of Education organised a competition to realize 51 new “Innovative Schools” placed all long the peninsula. Selecting these schools the municipality of Negrar (neighbouring Verona) was chosen among those who would had the funds to demolish a prefabricated school built around the Seventies of last century, currently in use but with considerable maintenance problems. This building will be replaced with a new one to serve as a model for other schools in the Veneto Region. The school illustrated in the paper was taken as study case by some researchers of Iuav University of Venice, assuming the correct use of colour and light essential for student’s wellbeing. The opportunity of the design competition, in which the researchers participated, served as a validation of the research hypotheses on colour.

Keywords: *Colour in Schools, Human Comfort, Innovative Schools, Negrar case*

INTRODUCTION

The Negrar secondary school currently used is dedicated to middle lower education for children aged between 11 and 14 years (three years). In the requirements of the competition for 51 “Innovative School” organised by the Italian Ministry of Education on 2016 was specifically requested: “conception and creation of spaces from the perspective of individual wellbeing...” i.e. human comfort. It is known that human comfort is a priority issue that involves colour and light in addition to the form, orientation, exposition, and many other aspects of a building.

At IUAV the authors are/were involved in some researches about schools consisting in: researches on Colour of Schools (Zennaro, 2015); members of the Research Unit Colour and Light in Architecture; tutors in graduation thesis in architecture (Niero, 2010; Corli, 2012, Langella, 2015); during the academic year 2014-2015 teachers at the Laboratory of Architectural Design and Innovation training an exercise oriented to design innovative schools in Negrar. The authors have also been involved in some public schools consultancy. These experiences were used to implement the competition project.

Since the school is used for a limited period of time – in Italy from September to June - and frequently only in the morning time, the project team has decided to give to the building the function of civic centre and sports facility that can be used even by the people of the local community when the school activities are suspended.

A precise chromatic study was designed to meet the needs of children, depending on age, adapting the public spaces to relational processes. In short, every interior space has been adequately investigated from the point of view of colour, lighting and orientation to respond to human comfort.

The building is placed on the boundary between a densely populated area and the cultivation of the vineyards that characterize the Valpolicella (Valpolicella is the first Italian appellation by value in red wine production, so the main activity in Negrar is the production of the famous wine "Amarone"). The exterior of the school was designed to be an interface between natural and artificial environment, less invasive as possible. At the same time, the design team has not neglected the aspect of representation of the dual public function (school and civic centre).

Another fundamental aspect was to understand the new teaching and research trends. In fact, the transformation of the school spaces, enriched by digital technologies, implies a rethinking of the architectural spaces. Currently, the students' sitting desks are generally opposed to the chair from which the teacher speaks. This provision makes the lesson practicable in terms of transmission of concepts and notions from one (the teacher) to many (the learners). This "obviousness" of the traditional classroom today tends to be overcome together with books, or in their replacement. In fact, new technologies have burst through and very quickly they are supplanting the traditional transmission of knowledge. The size of information available on the Web and its complexity requires a rethink to learn how to "navigate" in an unknown sea. Starting from these considerations and from disciplinary approaches we have applied the request for flexible environments and cooperative spaces. In fact, studies and researches published by the OECD refer to aspects of cooperative learning, flipped classroom and multi-dimensional teaching units, where there are: the agora (for common activities), the cave (for individual study), the laboratory, and other places as theorized by Nair, Fielding & Nackley (2013).

Given these assumptions the project has outlined a type of school certainly different from the traditional one, knowing that a change cannot be radical, especially for the Italian reality. Great importance has been given to the use of colour as a generator of wellbeing and definition of functions.

THEORICAL APPROACH

In the colour project the following cultural references were taken as the basis for the development of the concept:

- **Jorrit Tornquist,** maintains that the colours and light choice must be developed according to the **students age**. Colour in nursery schools and other levels of schools should not have a decorative function but should aesthetically coordinate things and situations, help orientation in space, regulate the behaviour of pupils, teachers, parents, and ease the identification of the environment. In addition to offering clearly visible indications, it should be important to **create**

different sensory situations, in opposition to anonymous and repetitive conditions.

- **Frank Mahnke,** in turn, considers that children aged **between nursery schools and primary schools** are more extroverted. For them a colour scheme would be indicated with bright and warm colours because they reduce nervousness or any tension. In schools and secondary education institutions the use of softer and cooler colours is recommended to increase concentration skills. Any **visual interference** inevitably affects learning performance.
- **Heinrich Frieling,** states that psychological colour tests have shown that the acceptance or rejection of certain colours is reflected in the progressive development of the child in adulthood. He has subjected tens of thousands of children and young people from all the countries of the world to his tests (slowly disused and replaced the Lüscher test). The discoveries of the scientist indicate which colours could be the most suitable in a school environment taking into account the different age of groups. In general, Frieling noted that children between **5 and 8** years old refuse black, dark brown and white, preferring colours close to red, orange, yellow and violet. The boys between the ages of **11 and 12** do not like the achromatic colours (black, white, grey) and prefer olive green, violet and lilac. The preferences of the boys and girls between **13 and 14** years went to the tones between blue, ultramarine and orange.
- **Peter Barrett,** has carried out a considerable research in England with the HEAD project. Survey carried out on 3766 English primary school children. Of great importance is the demonstration that there is an explicit **relationship between the physical characteristics of school buildings, the spaces within them and the learning performances**. Poor school building conditions are likely to raise a complicated situation, for teachers it becomes more difficult to teach and for the pupils to learn. Every stylistic effort must therefore be carried out with the intention of **creating the ideal conditions for learning**. When a new building is complete and is handed over to the teachers, one can only speak of a "finished beginning", to which the adaptations linked to the function of the school must be added. There are many proven ways to use colour in space, based on how colours contrast and mutually improve, based on how colour temperatures are juxtaposed and how our eyes are trained and arranged to accept the tricks of optical perception.

How to behave in the design and construction of new school buildings comes out from these studies and give some suggestions. This list, not exhaustive, advises:

- A full spectrum light fosters a decrease in hyperactivity.
- It is advisable to use poorly saturated colours in spaces where good vision is needed.
- It is preferable to use warm colours in cold places and cold colours in warm places.
- Environments should have different colours depending on their function and their users.
- Avoiding the disorder effect considering that the school environment is a changing environment.
- The spaces must be designed in colour in order to favour orientation.
- Passageway and transit spaces can have a wide choice of colours.
- In the classrooms where all the students are facing in the same direction, it is useful to foresee the front wall of a different colour from that of the side and bottom walls.
- It is preferable that the colour of the walls is opaque.
- The ceiling must be mainly monochromatic.
- The floors should be monochromatic, or basically monochromatic, and have a solid

appearance so as not to create insecurities in the pass.

- In the classrooms prefer natural incident light at 45 °.
- Worktops are preferable in opaque colours to avoid the glare effect.
- Avoid warm colours (such as red) inside gyms or classrooms for physical education.
- It is necessary to provide the lighting system with solar spectrum lights depending on the colour environment and vice versa.
- It is advisable to not use neon lights because they emit frequencies producing physiological discomfort.
- To create reflective colours, the effect given by frames or frames of coloured windows is preferable.

THE PROJECT OF THE INNOVATIVE SHOOL OF NEGRAR

The project of the new innovative school of Negrar has been developed through a configuration summarized in figure 1.

A dual approach to the specific colour has been set for the different user groups (teenagers, adults) and dedicated in relation to the functions and destinations of use of the spaces.

Spaces for learning: neutral colours; low saturation

A neutral colour approach was chosen to promote concentration. On the walls, white and pale colours have been chosen, with low saturation, while the eco-sustainable PVC floors are coloured blue or grey for space categories.

Link, connect, passageways and transit spaces: primary colours, high saturation

It is expected to use primary colours: yellow, red and blue with high saturation, to activate and encourage socialization, thanks to the stimulating power of colours.

For vertical surfaces: blue, yellow, and red. For horizontal surfaces as floors: grey, used in graphic terms to help orientation and mobility way finding.

Figure 1: Colour design of the Negrar school project.

Public spaces: secondary colours, high saturation and achromatic colours

In public spaces (atrium, piazza, agora, etc.) secondary colours are used: purple or green and orange with high saturation that, thanks to the stimulating power of colours, favour socialization. The same effect is obtained with achromatic, black and grey colours, or their optical combinations.

Outdoor spaces: neutral colours

In the external spaces (ways) neutral colours are adopted as grey or intrinsic colour of the used materials (green, wood, earth, glass, etc.).

CONCLUSION

The project of a school requires each space to be focused on ease learning and produce wellbeing. Color and light play a major role in this area. As the school is changing fast we can no longer think of spaces strictly according to functions, but to great flexibility. Temporary subdivision and functional organizations are more useful than partitions where the walls and barriers separate the learning spaces. In fact, even the current partition by age tends to be overcome by managing ability of pupils for their intellectual, theoretical and practical specificity.

Therefore the classes should be crosscutting and allow fast progress in studies of gifted children while bridging students' abilities with some gaps. The colour can provide a useful reference point, both by facilitating the propensities, but also as a tool for teachers to understand the subject with which they deal. Psychology, pedagogy and neuroscience become design instrument for architects. An experience of this kind is pursuing a master's degree at the IUAV in Venice. The Negrar case study was important to the challenge that has compared unusual assumptions and assesses the impact that the proposed solutions can have on a context strongly reluctant to change.

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colour & human comfort

Acceptable Size of Advertising Fascia based on Colour and Design in Historical Urban Areas in Kyoto, Japan

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ABSTRACT

Aims at historical urban area and surrounding regions, considering both the coordination of whole city and identity of outdoor advertising, the restriction method of outdoor advertising was surveyed based on the regulations. With the historical areas in Kyoto, Japan as the research objects, an impression evaluation was conduct to clear the relationship between outdoor advertising colours, colour combination of background and text colour, design and size. Based on the result of impression evaluation, colour in different hue, value and chroma could be accepted in different size. And the shape design also effected the acceptability of outdoor advertising. That means, the acceptability of outdoor advertising could be improved by adjusting the colour, size and changing the shape.

Keywords: *Advertising Fascia, Colour Acceptance, Design, Advertising Restriction*

INTRODUCTION

In accordance with the outdoor advertising restriction regulations, bright brand colours were forbidden with outstanding features in historical area, while there is compulsive requirement to use the historical colour of 'brown'. For restriction of outdoor advertising colour, it is mainly restriction of the background colour, or the colour used in most area[1)]. For restriction of shape, no matter what shape it is, the size is calculated based on the longest side length. There were no regulations or researches on the relation between the advertising colour, shape design and the acceptable size.

Then, some historical areas are developed as tourist attractions, or the surrounding region of historical area has certain requirement for using the different advertising colours.

Based on this situation, with the historical areas in Kyoto, Japan as the research objects, an impression evaluation was conduct to clarify the relationship between outdoor advertising colours, colour combination of background and text colour, design and acceptable size. By comparing the acceptability of different outdoor advertising, this study summed up the characteristics of outdoor advertising with high acceptance.

PREVIOUS RESEARCHES

Sakahara *et al.* [2] conduct questionnaire investigation of clashing colour from the perspective of architectural planning. They put forward the clashing colour by using the colour chart. However, the colour chart used in the research without considering the background buildings.

Yamamoto *et al.*[3] discuss colour combination of billboards rated with a high level visual attractiveness, concluding that the visual attractiveness of achromatic colour is higher that chromatic colour. However, in this survey, they pointed that billboards rated with a high level visual attractiveness were difficult to coordinate with the landscape.

Maki[4~5] experiments with the suitability, visibility and logo identity of existing signboard by using the pole signboard in historical street, office area and street in countryside. He suggests the evaluations of signboards in those 3 place should be different. However, he did not discuss the characteristics of high evaluation signboards in historical street.

METHODOLOGY

With the traditional wooden architecture of Chaya machi in Kyoto- Gion Shinbashi as the subject, based on the building elevation, the study worked out the experimental images in consideration of the surrounding environment. The images included 3 traditional buildings. Advertising fascia has been added on the one in the middle and its colour, size and design have been changed.

The experiment was divided into 2 steps. First, as shown in fig.1(a)-(b), the relationship between the background colour and the size of the advertising fascia was tested. According to the Munsell colour system, the hues of colours were divided into R, Y, G, B and P. The areas of advertising fascia used in this experiment were 1%, 3%, 5%, 8% and 10% of the actual areas of the front walls. As shown by the table 1, altogether 63 images were used in this experiment.

Then, the colour combination of background colour and text colour and the shape design were considered. The design and colour combination was shown in fig.1(c)-(d). Combined with 9 designs and 34 colour patterns, 43 images were used in this experiment.

3 evaluation items were used for first evaluation experiment, namely traditional colour, coordination and acceptability. Every item was evaluated through the 7-stage answering of the Semantic Differential Method. Then, Magnitude Estimation Method was used to do the evaluation in second experiment. There were also three items to evaluate: coordination, visual attractiveness and acceptability.

a. surface size 1%, 10B 3/4

b. surface size 5%, 10R 6/4

c. shape design   d. colour combination

Figure 1: Experimental Images with different colour, size and shape design.

	Value	Value	Value	Chroma				
	3	6	8	3	6	10	11	12
R	10R 3/4	10R 6/4	10R 8/4		10R 5/6	10R 5/10		10R 5/12
SIZE	1%, 5%	1%, 5%	1%, 5%		1%,5%,8%,10%	1%,5%,8%,10%		1%
Y	10Y 3/4	10Y 6/4	10Y 8/4		10Y 5/6	10Y 6/10	10Y 8/11	
SIZE	1%, 5%	1%, 5%	1%, 5%		1%,5%,8%,10%	1%,5%,8%,10%	1%, 5%	
G				10G 5/3	10G 5/6	10G 5/10		
SIZE				1%,3%,5%	1%,3%,5%	1%, 3%		
B	10B 3/4	10B 6/4	10B 8/4	10B 5/3	10B 5/6	10B 5/10		
SIZE	1%, 5%	1%, 5%	1%, 5%	1%,5%,8%,10%	1%,5%,8%,10%	1%		
P				10P 5/3	10P 5/6			
SIZE				1%,3%,5%	1%,3%,5%			
N	N3	N6	N8					
SIZE	1%, 5%	1%, 5%	1%, 5%					

Table 1: Colours and Size.

The respondents were divided into the profession, field experience and acceptability of advertising board colours. There were altogether 80 participants in first step and 20 participants from University of Tsukuba in second experiment.

The environment was carried out in a standard D65 luminous environment and at an illumination intensity if 1100lx on desk surface. In order to clearly indicate the overall colour of the buildings, and better comparison with the reference picture, this experiment used 15cm*30cm printed pictures. The 8-color inkjet printer was used to print the experimental picture and the colour was checked by JIS colour chart after printing.

ANALYSIS OF RESPONSES

Background attributes of the respondents was analysed firstly. Then we conducted correlation analysis of three evaluate items. At last, we conducted data analysis on the acceptability of advertising fascia.

(1) Analysis of Backgrounds of the Respondents

First of all, the study analysed answers given by respondents with different background attributes in this experiment. There was no significant difference in the analysis results. In other words, the experimental results were consistent. Therefore, we analysed the mean value in this experiment.

(2) Correlation Analysis of Evaluation Items

Every image was evaluated based on three items: traditional colour, coordination and acceptability. Subsequently, a correlation analysis was done on the three items. When $p<0.01$, the correlation coefficient between traditional colour and acceptable value was 0.976, and the between coordination and acceptable value was 0.984.

In second step, when $P<0.01$, the correlation coefficient between coordination and acceptable value was 0.981.

(3) Acceptable Size and Value

With the area range of 1%~5%, chroma 4, hue R, Y and B, there were significant differences between value 6 and 8. When value was about 8, the acceptable value of newly added advertising fasica colour decreased to below 0. Achromatic colour, N, did not experience such a change. Therefore, when the area was within 5%, if the value of chromatic colours was above 6, then the colours were unacceptable. However, there was no value restriction when it came to achromatic colours.

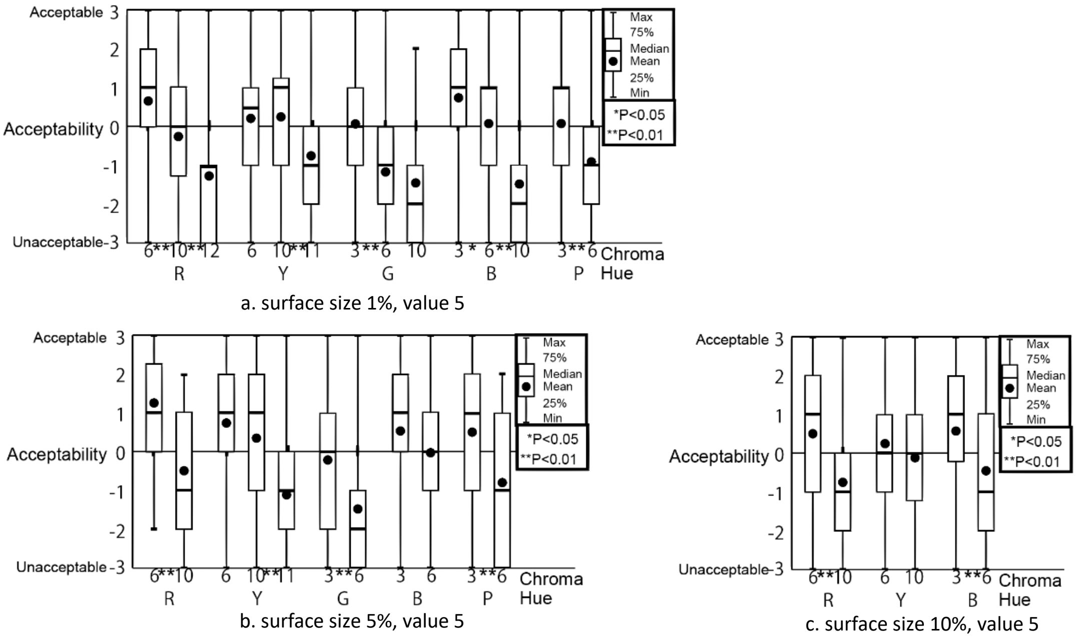


Figure 2: Acceptability for Fascia Colours of Different Chroma.

(4) Acceptable Size and Chroma

Fig.2 reveal the acceptable value of advertising fascia colours with different chroma. The size was divided into two intervals, namely 1%~5% and 8%~10%, and chroma of each hue was analysed within the two intervals.

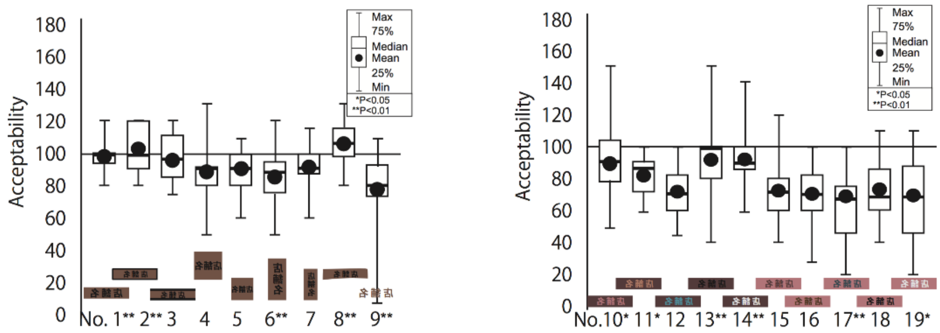
When the size was within 1%~5%, there were significant differences between hue R, chroma 6 and 10. When the chroma was 10, the acceptable value was negative, i.e. disallowed. The significant difference judgment of hue Y occurred when the chroma was between 10 and 12. When the usable area was between 8%~10%, the significant difference judgment of hue R was between chroma 6 and 10. Hue Y did not have any significant difference. The significant difference judgment of B occurred between chroma 3 and 6. Thus, when the area was over 5%, hue R was allowed within chroma 6, hue Y was allowed within chroma 10, and hue B was allowed within chroma 3.

(5) Acceptable Design

According to the fig.3(a), it is clearly showed that the acceptability of images of No.1, No.2 and No.8 was better than the others. Acceptability of image No.9 which designed in channel letters was the lowest.

(6) Acceptable Colour Combination

When we used the R as the base colour(fig.3(b)), the acceptance of advertising was little lower than reference 100. Base colour of low value, low chroma which had a higher acceptability than average. From the fig.3(b), dark base had a higher acceptance excepted No.12 which used the comparative blue in text.



a. acceptable design

b. acceptable colour combination (Hue R)

Figure 3: Acceptability for Shape Design and Colour Combination (Hue R).

In hue Y, acceptability of No.22 which used low value, low chroma colour as the base colour and comparative blue was lower that the other colour scheme. When we used the B in base colour, the acceptance value of advertising board with low value and low chroma base colour and white and black text was higher than others. When achromatic colours were used in the base, the grey in middle value was more acceptable than white and black.

CONCLUSION AND DISCUSSION

In this experiment, there was no difference between acceptance value of colours caused by different respondents. In other words, the acceptable tendency of colours was unified no matter what the respondents.

Traditional colour, coordination and acceptable value of the evaluation items were highly correlated. That is, if the respondents thought the colour accorded with traditional or coordinated colour, their acceptability of the colours would also increase.

Based on the first experiment, the following conclusions were reached about colours accepted by historical areas based on the size (See Table 2).

	Value (chroma 4)		Chroma		
Area	< 5%	< 10%	< 3%	< 5%	< 10%
R	< 6	-			< 6
Y	< 6	-		< 10	X
G	-	-		< 3	-
B	< 3	-	< 6	< 3	< 3
P	-	-		< 3	-
N	o	-			
o Accepted for all values ; - Not tested ; X Rejected ;					

Table 2: Colours and Acceptable Size.

Based on the second experiment, the characteristics of high acceptable outdoor advertisings are summarized as the following:

1) using the natural wooden shape could make the advertising more acceptable.

2) using traditional visual elements can also increase acceptability.

3) advertising fascia that does not use background boards, such as channel lettering, should be avoided.

4) using the colour of hue R~Y as the base colour, low value and low chroma was easier to be accepted. For the texts, it was not recommended to use comparative B colour.

5) using the colour of hue B as the base colour, similarly base colour of low value and low chroma was easier to be accepted. In this case, achromatic colours were recommended for texts.

6) when the base colour used achromatic colour, grey was more acceptable than others.

Based on the results, the acceptability could be improved by adjusting the colour, size and design of outdoor advertisings. However, the advertising fasica was used in this research, and the other types of advertisings should also be discussed in the future.

The experimental images were printed in 15*30mm. We speculated that the suggestions to improve the acceptability of advertising can be applied to actual used, but the colon data should be determined by different situations.

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Colorimetry

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State-of-the-art Measurement and Quality Control of Colours with Special Effects towards Comfort and Aesthetics for End Users

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ABSTRACT

In the last couple of decades, paints formulated with special effects pigments have been developed as to provide end users with a customised touch for their ultimate satisfaction in terms of comfort and aesthetics. Since then, a variety of state-of-the-art technologies have been employed for enhancing the colour measurement and quality control of paints with special effects by dealing with factors like: gloss, total appearance, pearlescent and metallic effects, aesthetics, among other variables during design, laboratory, production, marketing and commercialization. This is all about satisfying the needs of an end customer - who wants a paint that matches a colour from a piece of painted wall - or to fulfil a big production order for a major manufacturer of automotive paints. This work lists state-of-the-art technologies for colour measurement and quality control of paints with special effects pigments towards the wellbeing and full satisfaction of the modern and well-informed consumers.

Keywords: *paints, effects, quality, appearance, colorimetry*

INTRODUCTION

The most advanced technologies from different scientific and industrial domains represent what has been called the 'state-of-the-art' of each sector. These advanced technologies seek to materialize, for example, in the form of instruments and equipment (hardware) and/or programs and computerized applications (software), the current expertise of each respective domain of knowledge to solve production problems related to some special market requirements - or even to leverage the good development and progress of pure research.

This article seeks to describe some state-of-the-art technologies as main solutions currently offered by major leaders from the colour measurement and control sector to companies that manufacture paints with special effects pigments. The big 'popes' and pioneers in the field of Colour Science and Colorimetry have been through a long way studying how to deal with the physical phenomena of this type of specialized paints. Starting from the vast literature that supports theories and methodologies of traditional colorimetry and colour quality control, theoretical and mathematical representations created by the big names in this domain are already exhaustively described and studied in the form of tristimulus values, spectral reflectance, colorimetric coordinates, equations for calculation of colour difference, metamerism, included and excluded specular component, thermochromism, opacity, transmittance, yellowing index, whiteness degree, colour tolerances, gloss, among other fascinating subject matters related to colours (MacAdam, D. L. 1942; Hunter, R. S., 1948; Billmeyer F. W. & Saltzman M., 1966; Judd D. B. & Wyszecki G., 1975; McDonald, R. 1987; Kühni, R. G., 2003). These well-established Colour Science and Colorimetry are currently in full and effective practical usage in many industrial sectors, and also serve as the basis for new developments aiming its application to unconventional colours with special effects and finishings, which are the object of our interest.

This article gives a glimpse of how have been managed the intrinsic difficulties of measuring and controlling the quality of colours with special effects in relation to factors inherent to the newly-studied reflective and translucent physical characteristics and properties which have been added to paint products as to cope with the current global markets' demands and requirements towards the wellbeing and full satisfaction of the modern and well-informed consumers. In addition, this article seeks to provide a brief overview of what is currently available in the market of paints with special effects in terms of state-of-the-art products and solutions for specification and design, development and formulation, as well as for production and quality control in order to obtain colour products in a consistent and reproducible manner, towards meeting specific aesthetic requirements from end customers.

ISSUES RELATED TO COLOUR MEASUREMENT AND QUALITY CONTROL OF PAINTS WITH SPECIAL EFFECTS PIGMENTS

As indicated by the vast literature available in the field of traditional colour measurement and quality control, it is evident that the colorimetry of opaque samples, mainly dyed or pigmented with 'flat' or 'spot' colours - and without optical effects - is a science already well described by many professionals in the academic and industrial sectors. However, our world is not made only of uniform colours. How dull would our physical world be if there were no peacock's feathers with their beautiful iridescent colours, or the nacred colours from molluscs and their mother-of-pearls, or the metallic colours from shells or bodies of some curious insects? Also, many industrial companies would not be what they are today if there were no colourants with special effects for diversifying the colour palettes of their products, like in the case of automotive, plastics, printing, cosmetics, and paints and coating industries.

There has been a time when the first generation of colourants with traditional, classic effects were enough to provide coloured products to satisfy all popular demands. However, consumer markets all over the world became more and more dynamic, well informed, wealthier and, thus, eager for novelties in terms of more appealing, colourful products. According to a recent report on the global and regional market forecasts for special effect pigments by type (metallic/pearlescent) and by application (plastics, paints and coatings, inks and cosmetics), the market is foreseen to grow from an estimated US$750 million in 2017 to about US$970 million by 2022 (MarketsandMarkets, 2017).

It has been found that designers and stylists, during their product creation processes, are demanding the use of high-performance colourants that generate more and more 'modern' and eye-catching special effects. Accordingly, out of their modern research and development laboratories, colourant manufacturers from leader countries in this sector are regularly launching new dyes and pigments that provide better durability, opacity and heat stability, light and weather fastness, chemical and migration resistance or other attributes not found in lower-cost colourants as to meet such technological demands (Diamond, 2015). Cramer & Gabel (2001) gave an overview of major types of special effects pigments that have been launched in the market at the beginning of our 21st century. These novelty pigments would represent the main components of modern paints due to the unique characteristics that this type of colourants impart to colour appearance and visual perception. These above-mentioned authors pointed out that conventional pigments based on aluminium and on tin-copper alloys have been replaced by so-called pearlescent or nacred pigments, which are based on mica, a mineral from the phylosilicate class.

According to the previously-mentioned authors, pigments can be generally classified as metallic, silica-metal, and liquid crystals, each type showing a different kind of effect that cannot be explained here due to the mandatory maximum length of this article. More details can be seen then in the corresponding Poster. According to Cramer (1999), although there are many sharp differences between the ways in which pigments with special effects are manufactured, their optical properties can be fully explained in terms of a physical phenomenon called 'interference'. The incident light on a colourant undergoes a partial reflection from its surface and a partial refraction through it. This causes shifts in the wavelengths of individual light rays and generates their merge with each other, thus creating interference-related physical phenomena.

Figure 1 illustrates the phenomena of the two types of interference. In the constructive type, the peaks of each wave converge, thus increasing the amplitude's intensity and creating that above-mentioned system of fringes. On the other hand, in the destructive type of interference, a valley of one wave encounters a peak of the other one, thus partially cancelling the resulting amplitude to form the previously-mentioned standing wave. Complete cancellation occurs only if the wave signals are perfectly out of phase which, in practice, never occurs.

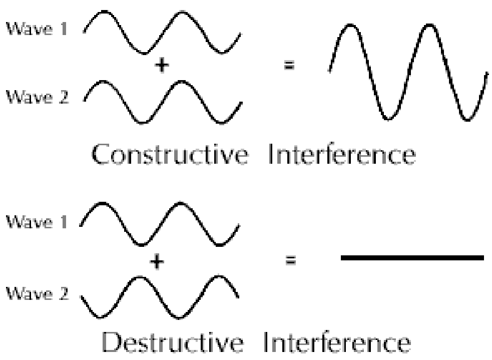

Figure 1. The phenomena of the two types of interference: constructive and destructive
Source: University of Tennessee, Knoxville, USA.

This physical phenomenon provides the fundamentals for the development of an equation that indicates the place of maximum reflection and, therefore, the resulting colour as a function of the calculation of the shift that occurs under simple and ideal conditions. The factors of such equation are the thickness of the layer of titanium dioxide, responsible for the refraction, the refractive index and the angle of the incident illumination. As the thickness of the metal oxide layer increases, the colour of the pigment changes from silvery white to yellow, red, and blue to green resulting in the desired, beautiful effect (Cramer & Gabel, 2001).

There are two fundamental types of chromatic shifts that can be perceived in the case of interference pigments: aspecular and interference *per se* (Cramer & Gabel, 2001). The first one, aspecular shift, is typically produced by keeping the incident illumination angle constant (for instance, at 25° or 45°) and varying the aspecular angle. The term aspecular - thus referring to the viewing angle - is also known as 'degree from gloss', 'cis-trans position' or 'angle of effect'. The second effect is the interference shift which is generated by varying the illumination angle and keeping the aspecular angle constant (for instance, 15° from the gloss angle).

More recently, Rahman and Johnson (2008) have added two new types of physical effect colourants that have been the subject of intense research for their effective industrial use, taking inton account the wide versatility and higher uniformity of the colour effects that they can generate: nanoparticles and photonic crystals. Again, more details are available in the corresponding Poster.

INSTRUMENTAL SYSTEMS FOR COLOUR MEASUREMENT AND QUALITY CONTROL FOR PAINTS WITH SPECIAL EFFECTS

A study conducted by Gabel & Pieper (1992) indicated that the measurement geometries provided by the colorimetric instruments from the last decade of the 20th century were adequate to deal with the first generation of special effects pigments. Another study indicated that, at that time, there was a small number of 'problematic' interference pigments which colour characterization and quality control did not perform well by means of reflectance spectrophotometry (Gabel, Hofmeister & Pieper, 1992). Some technology companies that manufactured cutting-edge spectrophotometers at that time based on measurements done under different illumination and viewing angles were: Datacolour, Gretag-Macbeth, Instrument Systems, Minolta, Murakami, Optronik, Phyma, X-Rite Inc., and Zeiss. While innovative special effects colourants were being launched in the market and their instrumental characterization and measurement became increasingly more complex, then leader suppliers of spectrophotometric systems began accordingly to foster research and development of new hardware and software that would allow adequate results to be obtained. Such new solutions seek to take into account the physical properties and optical characteristics of these innovative colourants in question in order to meet the latest needs and requirements from a new, demanding, and wealthy class of consumers around the world. In order to obtain acceptable results for the desired purposes, all instruments employed must be able to measure the aspecular and interference colour shifts from special effects colourants. Therefore, illumination and observation angles should be used as close as possible in relation to the horizontal, "so as to better mimic the actual visual impression" (Pfaff & Gabel, 2005) by means of instrumental measurement data.

CONCLUSION

The Poster presentation illustrates a brief survey of the main cutting-edge solutions developed by leading manufacturers of computerized colour and appearance measurement and quality control systems designed for paints with special effects: Murakami GCMS-4, BYK-mac i Series Spectrophotometers, Minolta's RHOPOINT - TAMS^{TM}, and X-Rite's Total Appearance Capture - TAC^{TM} - all this with the aim of obtaining coloured products in a consistent and reproducible manner - towards the wellbeing and full satisfaction of the modern and well-informed consumers.

Therefore, paint and coatings manufacturers have a highly sophisticated technological 'arsenal' to meet the main special effects colour quality market requirements in line with the latest industry standards and customer demands. However, choosing the supplier of the most appropriate system for a particular application should not only be done taking into account the innovation and technological modernity of the system, but it is mandatory to carry out a comprehensive study which also takes into account documentation availability in local languages (hardware and software manuals, installation and operation guides, and so forth), possibility of system updating and scalability, sharing of measurement data between creation/design, laboratory, production, sale and retail systems, as well as the provision of theoretical and operational training for users. All this makes another subject matter to be covered in a new article in the near future.

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Spectral Skies: Towards a Novel Model to Describe Temporal Variability and Spatial Distribution of Spectral Daylight Characteristics

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ABSTRACT

Spectral power distribution of light plays a significant role in people's comfort, visual performance, as well as their psychological and physiological health. Yet, most daylight simulations rely only on photometric quantities. This paper presents a differentiated colorimetric approach based on direction specific spectral data. It opens with a review of existing spectral sky models and a comparison study of their accuracy based on a large dataset of spatially, spectrally and temporally resolved measurements conducted at the TU Berlin to conclude with the next steps towards a novel model to describe temporal variability and spatial distribution of spectral daylight characteristics.

Keywords: *spectral sky models; spatially resolved measurements; data-driven method; daylight characteristics; colorimetry*

INTRODUCTION

Spectral power distribution (SPD) of light can play a significant role in people's comfort, visual performance, as well as their psychological and physiological health. Yet, most daylight simulations to predict or investigate these visual and non-visual effects rely only on photometric quantities. The colorimetric information is typically reduced to a global spectral irradiance or set to a correlated colour temperature (CCT) of 6500 K. This implies a uniform distribution over the entire sky-dome, even though the spectral characteristics, and the resulting CCTs, are not only varying over time, but also depend on the orientation of the analyzed sky part. In order to include spectral characteristics in daylight studies, for example to incorporate new spectral weighting functions for non-visual responses or to assess the potential of spectrally selective fenestration materials, a differentiated colorimetric approach based on direction specific spectral data is necessary. This paper presents a review of existing spectral sky models and their accuracy based on a large dataset of spatially, spectrally and temporally resolved measurements conducted at the TU Berlin. The measurements and the comparison study of existing models are fundamental for the next steps towards a novel model to describe temporal variability and spatial distribution of spectral daylight characteristics.

REVIEW OF EXISTING MODELS

Takagi et al. (1990), Chain et al. (1999-1) and Rusnak (2014) suggest that the CCT of a specific sky patch corresponds to the sky patch's luminance. Takagi et al. first proposed the expression linking the luminance to the correlated colour temperature.

$$CCT = \frac{1{,}1985 \cdot 10^8}{\mathrm{L}^{1{,}2}} + 6500$$

where

L	luminance at any point of the sky $[cd \cdot m^{-2}]$
CCT	correlated colour temperature $[K]$

This formula is based on experimental measurement data conducted in Japan and according to Takagi and colleagues can be applied at any point of the sky under any weather condition.

Chain et al. (1999-1) present two novel models in which the relation between the CCT and the luminance differs depending on weather conditions, and thus sky type. These models are based on spatially resolved spectral measurements conducted in Lyon. The measurements were conducted manually with an aperture angle of 1° in 51 scans in 77 directions. Chain observed three major tendencies:

- for clear sky conditions: CCT values decrease as luminance values increase
- for overcast sky conditions: the CCT over the whole hemisphere can be considered uniform and set to a fixed value of 6415 K
- for intermediate sky conditions: blue and cloudy sky patches correspond with the behavior for clear and overcast skies respectively.

For clear skies the correlation between luminance and CCT was expressed with the fitting function, where the coefficients are the mean values observed for 36 series of clear skies:

$$CCT = \frac{10^6}{-132{,}1 + 59{,}77 \cdot log_{10}L}$$

For 6 series of overcast skies the fitting resolved to a mean constant value of:

$$CCT = (6415 \pm 133)\ K$$

Further refinement of the method (Chain et al. 1999-2 and Chain 2004) based on 101 single SPD measurements, and a long-term validation with measurements of five chromameters combined with measurements of the Lyon IDMP station, led to the introduction of a new parameter called Luminance Colour Factor (LCF). The LCF depends on the sky type and can be determined based on the sun height γ_S and Perez sky clearness ε (Chain 2004). Chain relates the CCT distribution to the luminance distribution using the Perez-All-Weather model (Perez et al. 1993) and propose one equation for all sky states.

$$CCT = \frac{10^6}{181{,}35233 + LCF \cdot (-4{,}22630 + log_{10}L)}$$

$$\mathrm{LCF} = 21{,}56308 + [82{,}33165 - 0{,}77050 \cdot \gamma_S] \cdot [1{,}10439 + log_{10}(\varepsilon - 0{,}9)]$$

where

LCF Luminance Colour Factor, factor of luminance to correlated colour temperature
γ_S sun height [°]
ε sky clearness according to Perez et al (1993)

Rusnak (2014) measured the spectral characteristics of daylight with a mobile spectral sky scanner. The luminance to CCT correlation draws upon the luminance distribution of CIE Standard General Skies in accordance with the ISO / CIE standard (CIE 2003). This standard defines 15 sky types for clear, overcast and intermediate skies with standardized luminance distributions. 89 scans in 145 directions according to Tregenza (1987) resulted in 12905 SPDs. One scan took approximately 5 minutes. Rusnak transformed the expression used in Chain 1999-1 and determined the coefficients for all 15 CIE sky types.

$$CCT = \frac{10^6}{pL^q}$$

where

q, p coefficients are the mean values of the empirical measurements per sky type

Concluding, there is a strong correspondence between the luminance of a sky patch and the correlated colour temperature, which was further confirmed by measurements in Berlin (Knoop et al. 2015). For now, this L to CCT relationship is reflected in empirically fitted spectral sky models for three locations: Vaulx-en-Velin in France, Bratislava in Slovakia and Japan (the exact location was not stated), for which the conditions are summarized in Table 1. Nonetheless, these models show considerable differences in predictions of CCTs for clear skies (figure 2). The reason for this could be the validation with datasets from the same location, whereby some sky conditions might not have been sufficiently represented. This discrepancy can also be a result of a low amount of SPD measurements (under 100 series) per location and short length of recording. Furthermore, the maximum measuring time set by the CIE 1994, to scan one sky hemisphere, was not kept. For improvement of the fitting, further collection of data with a shorter scan time, over a longer period of time and for more locations is needed.

Table 1: Summary of existing models based on the L to CCT correlation.

Paper	Measuring site	Length of record	Number of SPDs	Series of measurement	sky division	aperture angle	Scan time	Relates to luminance/ radiance model
Takagi et al. 1990	Japan	unknown	unknown	unknown	unknown	unknown	unknown	-
Chain et al. 1999-1	Vaulx-en-Velin, France	Apr 1997-Sept1997	3927	51	77	1°	5 minutes	-
Chain et al. 2004	Vaulx-en-Velin, France	Okt 1999 - Dec 2000	none, just x,y color coordinates	11388	5	20°	unknown	Perez-All-Weather Modell
Rusnak 2014	Bratislava, Slovakia	2011-2012	12905	89	145	11°	5 minutes	CIE Sky Types

EXPERIMENTAL SET-UP

A spatially and temporally dynamic light source such as daylight sets particularly requirements for the measuring system. Spectral irradiance or radiance measurements must be carried out in short time frames. To combine luminance measurements with this spectral information, it is recommended to adopt the time frame for luminance measurements according to CIE (1994), set to an upper limit of 2,5 minutes. The subdivision of the sky hemisphere according to Tregenza (1987; CIE 1994) results in 145 sky patches. The spectral irradiance is to be measured within a maximum solid angle of 0,0289 steradian (11° aperture angle), for a bandwidth of 280 – 830 nm. With these specification requirements a spectral sky scanner was built. It is one of the few measuring sites in the world gathering this kind of data. Spatially and temporally resolved spectral daylight measurements have been carried out at the TU Berlin since October 2014. Every second minute, the spectral sky scanner measures the SPD, between 280 nm and 980 nm, of light from 145 sky patches distributed over the entire sky-dome. The duration of a scan is one minute. Up until now, this resulted into over 30 million daylight spectra, and the measuring process is still ongoing.

The spatially resolved SPD measurements collected at the TU Berlin allow to verify the accuracy of the interrelation between the luminance and the CCT of a sky patch being subject to prevalent sky conditions of existing models. The research follows the big data approach. For this, specialized data analysis and representation tools, as well as a database were developed. We derived the luminance, chromaticity coordinates and CCT of each sky patch and model the relationship between luminance and CCT based on the SPD measurements for the 145 sky patches per scan (Figure 1). The research at the TU Berlin draws upon the CIE standard skies, which were derived from the luminance distribution as proposed by Kobav et al. (2003).

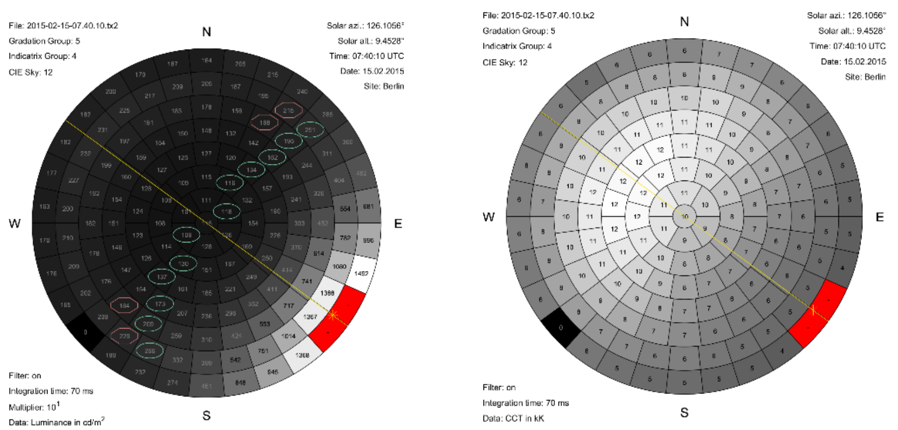

Figure 1: Exemplary luminance and CCT distributions for a clear sky; Berlin 15 February 2015.

RESULTS AND DISCUSSION

The models by Takagi et al. (1990), Chain et al. (1999-1, 2004) and Rusnak (2014) were used to predict the CCT based on the luminances derived from the measurements conducted in Berlin. The predicted values were subsequently compared with the measured data. For the comparison two sky types were considered, the CIE 12 (clear sky) and the CIE 3 (overcast sky) Standard General Skies.

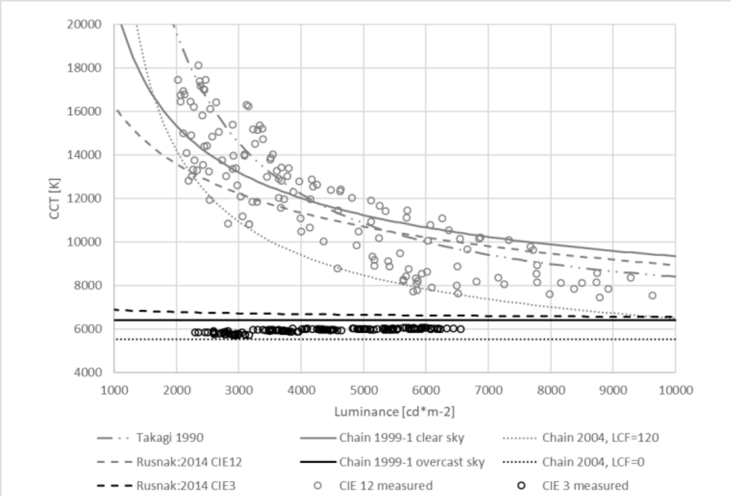

Figure 2: Relationship between the fitted models and measured data for clear and overcast skies.

For the analysis presented in this paper, only measurements between 1 January 2016 and 31 December 2016, for sun heights γ_S above 10° and UTC between 9:00 and 13:00 were taken into consideration. This resulted in 58548 measurements for clear and 625688 for overcast skies. The relationship between the fitted models and the measured data is shown in Figure 2. Table 2 shows the mean absolute deviation (MAD) and root mean square deviation (RMSD) between measured and predicted values for clear (CIE 12) and overcast (CIE 3) sky conditions.

Table 2: Mean Absolute Deviation (MAD) and Root Mean Square Deviation (RMSD) between measured and predicted values for clear and overcast sky conditions.

Spectral Model	MAD for CIE 12 [K]	RMSD for CIE 12 [K]	MAD for CIE 3 [K]	RMSD for CIE 3 [K]
Takagi et al. 1990	2575	3734	14721	19707
Chain et al. 1999-1	1893	2532	384	564
Chain 2004	2182	2719	661	829
Rusnak 2014	1852	2421	641	759

MAD and RMSD are used to estimate the discrepancy between predicted and measured CCT values. The comparison between the modeled and measured data for clear sky conditions shows no significant variation of the resulting RMSD and MAD for all fittings. All models show relatively high MAD and RMSD values. For overcast skies the model introduced by Chain et al. (1999-1) performs best. The relationship between computed and measured CCTs for Chain (2004) and Rusnak (2014) are comparably good. The comparison showed that the Takagi model is unreliable for overcast skies.

CONCLUSION

In this paper, we presented a differentiated colorimetric approach based on direction specific spectral data. The review of existing spectral sky models showed that further improvement in the measurements and validation of the models is needed. Based on a large dataset of spatially, spectrally and temporally resolved measurements gathered at the TU Berlin a comparative analysis between the predicted and measured data was conducted. This comparison showed that the fittings for overcast condition from Chain et al, (1999-1, 2004) and Rusnak (2014) were performing comparably good, whereas the Takagi et al. model is unreliable for this sky state. For clear skies no significant variation in MAD and RMSD values between the models were visible. The approach of Chain and Rusnak will be pursued further. The spectral sky models will be further refined and validated through TU Berlin measurements, which are measurements obtained over a longer period of time, within a shorter scan time. Refinement will focus specifically on the clear and intermediate skies. The spectral sky models will be validated for different locations with a mobile set-up that will collect L to CCT data in different parts of the world in the near future.

ACKNOWLEDGEMENTS

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Colour Discrimination Ellipses Explained by Metamer Mismatching

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ABSTRACT

Many psychophysical experiments have shown that colour discrimination varies substantially with the region of colour space in which the colours reside. Many models of the experimental data have been proposed, and many uniform colour spaces have been developed that attempt to represent colour in a coordinate system such that equally discriminable colours are equal distances apart, but all of them are based on fits to the experimental data. Many provide good fits to the data, but they remain data models and do not explain why colour discrimination varies in the way it does. In contrast, this paper outlines a theory of colour discrimination based on the uncertainties reflected in the extent of metamer mismatching. The greater its extent, the more finely a colour needs to be discriminated.

Keywords: *Colour discrimination, metamer mismatching*

INTRODUCTION

The threshold for discriminating one colour from a very similar one is known to vary as a function of the colour involved. This paper addresses the question of why colour discrimination varies as it does.

It has become common to represent colour discrimination in terms of ellipsoids in colour space or ellipses in chromaticity space. Chromaticity discrimination ellipses were initially measured by MacAdam [1], and his results first revealed the non-uniformity of the CIE 1931 colour space. Many other colour discrimination experiments have followed and have been used in the development and testing of several new uniform colour spaces and colour difference formulas.

Luo *et al.* [2] tested the performance of the CIECAM02 colour appearance model and introduced a modified version of it to fit what are known as the SCD (small colour difference) and LCD (large colour difference) data sets. Wen [3] proposed a method for calculating colour differences and showed that it outperforms CIEDE2000 in predicting threshold colour differences. Huang *et al*. conducted an experiment using 466 pairs of printed samples surrounding 17 colour centres to evaluate 10 colour difference formulas [4]. In another study, Luo and Rigg combined the data from different sources to produce a consistent set of ellipses [5]. Berns *et al.* [6] generated a colour-difference tolerance dataset of 19 colour centres for fitting and testing of colour-difference metrics. Sharma *et al.* [7] provided a data set for additional test on CIEDE2000 formula. Pridmore and Melgosa [8] analyzed four different data sets to model the ellipse area and dimension.

All of the models and uniform colour spaces derived from these experiments are based on fits to the experimental data. Many provide good fits to the data, but they remain data models and do not explain why colour discrimination varies in the way it does. What is the underlying reason that colour discrimination varies as it does? The hypothesis investigated here is that it is due to metamer mismatching.

HYPOTHESIS

Metamer mismatching refers to the extent to which two physically distinct reflectances that match (i.e., lead to identical LMS cone response colour signals) under one light fail to match under a second light. Metamer mismatching arises from the fact that normal trichromatic colour vision is based on only 3 weighted-sum measurements of the reflected light's spectrum impinging at any given point on the retina, whereas that spectrum—the product of the illuminating light's spectrum and the surface's underlying spectral reflectance function—is much more complex. The study by Zhang *et al.* [9] of metamer mismatching showed that it is most severe for grey and least severe for highly saturated colours. See Figure 1. Our hypothesis is that in order to be able to reliably discriminate physically distinct surfaces from one another observers must be more sensitive to the differences between colours for which metamer mismatching creates significant uncertainty (i.e., when the metamer mismatch bodies are large), and least sensitive for colours for which metamer mismatching creates little uncertainty.

The volume of the metamer mismatch body (MMB) (i.e., the set of all possible colour signals that can arise under the second light given the colour signal under the first light) for a given colour signal is a measure of the possible variability in the nature of the underlying physical reflectance. The larger the MMB, the larger and more varied is the set of reflectances that are all metameric (i.e., create the same LMS cone response) under a given light. Hence, for colours with large MMBs there is more uncertainty as to the exact nature of the underlying surface reflectance function. Intuitively, it is clear that there are likely more reflectance functions that lead to a mid-grey where the entire range of the visible spectrum is likely to be involved than there are to a saturated red, for example, where mainly the long-wave portion of the spectrum is likely to be involved. For an observer wishing to identify a given physical surface by its colour, it is therefore more important to distinguish the exact shade of a grey surface as precisely as possible and less important to distinguish the exact tint of a red one. Similarly, there are very few reflectances leading to pure white, with the limit being the ideal white created by a uniform 100% reflectance. In fact, for any colour signal on the boundary of the object colour solid, there is only one possible reflectance creating it, so the volume of the MMB drops to zero for such colour signals. This is illustrated by the plot in Figure 1.

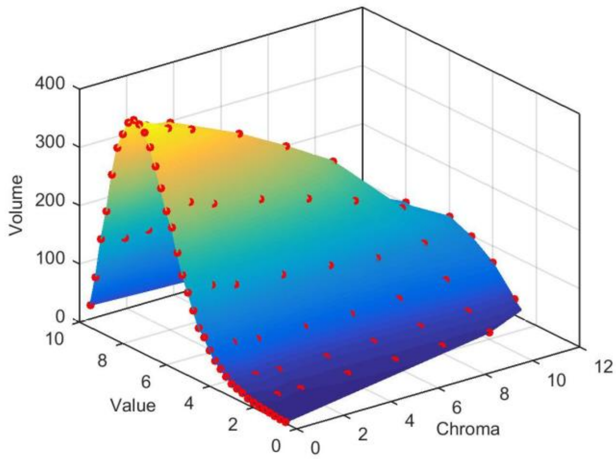

Figure 1: Plot of MMB volume averaged over all hues showing how the MMB volume decreases with distance in Munsell value and/or chroma from grey (value 6, chroma 0).

This trend of the MMB volumes is also clear in the xy-chromaticity plot of Figure 2, which shows how the size of the MMBs decreases towards the spectral locus (i.e., as the saturation increases).

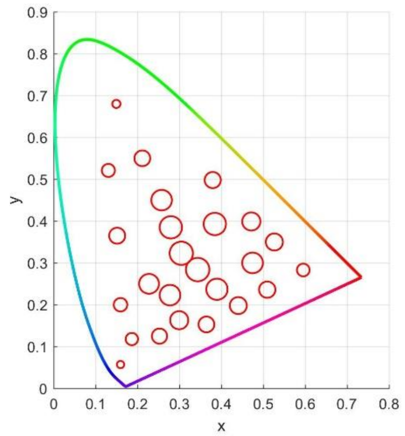

Figure 2: A plot in xy-chromaticity space of metamer mismatch body volumes as a function of colour centre, with the area of each red circle being proportional to the corresponding MMB volume.

RESULTS

Huang *et al.* [4] measured colour discrimination ellipsoids for 17 colour centres and Berns et al. [6] measured 19. While the experimental methods differed, both sets of experiments are based on coloured surface samples, not lights. These datasets are therefore useful comparison to predictions based on the MMB volumes.

The results of both studies are reported in CIELAB colour space. For comparison to the MMBs, boundary points of the ellipsoid in CIELAB are converted to CIE XYZ and then to LMS cone space via the Hunt-Pointer-Estevez matrix. The volume, E, is then computed as the volume of the convex hull of those boundary points in LMS space. For each colour centre, the volume, M, of the corresponding MMB for a change in illuminant from CIE D65 to CIE A is computed directly in LMS space using the algorithm of Logvinenko *et al*. [10].

In order to make comparisons in 'linear' space the cube root of both E and M are used as being representative of their 'radii'. The cube root of E is then normalized by the Euclidean distance, C, from the ellipsoid's centre to the LMS origin. This normalization eliminates effects due to the intensity/luminance and is similar to converting to chromaticity space. The hypothesis that metamer mismatching is at least partly responsible for the variation in colour discrimination as a function of colour centre then is evaluated by comparing E1/3 / C to 1/ M1/3.

This metamer mismatching hypothesis is then evaluated against the null hypothesis that there is no linear relationship between E1/3 / C and 1/ M1/3 for both the Huang [4] and Berns [6] datasets. The null hypothesis is rejected at the 5% significance level, with p-values in all cases being less than 0.006. The R-squared results along with plots of the fits are shown in Figure 3 both in linear and log-log plots.

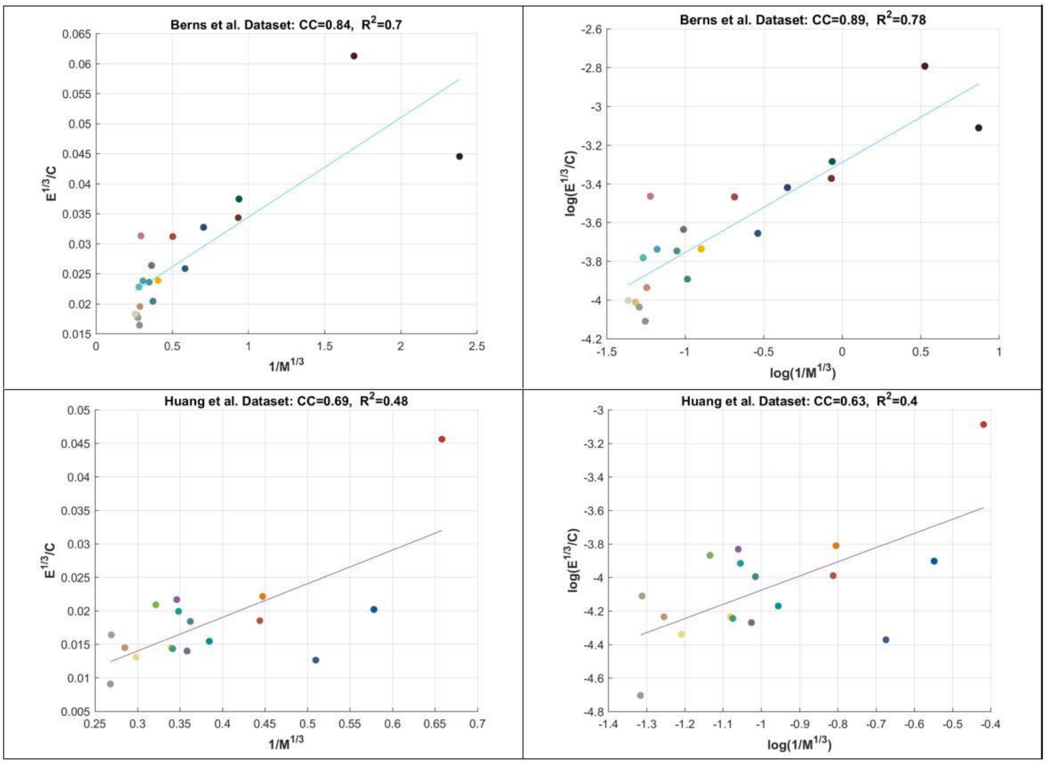

Figure 3: Plots of the normalized 'radii' (cube root of volumes) of the colour discrimination ellipsoids in LMS space as a function of the inverse of the radii of the corresponding metamer mismatch bodies for both datasets. The plot titles specify the correlation coefficient (CC) and R-squared (R2) for the linear fits.

DISCUSSION and CONCLUSION

It is common to represent colour discrimination in terms of ellipsoids in colour space and ellipses in chromaticity space. In this paper, two sets of experimental data on colour discrimination are used for testing. The results reported above indicate a correlation between colour discrimination and metamer mismatching. In particular, as the extent of metamer mismatching increases, colour discrimination thresholds decrease. The fits shown in Figure 3 do indicate the hypothesized relationship, but they are far from perfect. Of course, the experimental data contains noise, but other unaccounted for factors need to be considered and investigated. The fact that the Berns data is modelled better than the Huang data can be accounted for by the fact that the Huang data focused on measuring discrimination ellipses rather than ellipsoids. Huang *et al*. [5] specifically state that the ellipsoid volumes they report are likely to be less reliable than the ellipse areas.

This paper has explored the hypothesis that the need to overcome the uncertainty due to metamer mismatching is the reason for more precise discrimination between colours in some regions of colour space. Since Zhang *et al*. [9] showed that metamer mismatching is greatest for grey, high for colours of low saturation, and decreases with increasing saturation, the hypothesis correctly predicts that colour discrimination is finest near grey and coarsest for the saturated colours near the object colour solid boundary. In other words, metamer mismatching provides a possible explanation for why colour discrimination varies in the way it does.

ACKNOWLEDGEMENTS

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Digital Colour Management on a set of Human Skin Tones has an Irregular and Low Performance

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ABSTRACT

A DCM (Digital Colour Management system) ensures the best colour match between colour representations. In a DCM, the CP (Colour Profile) is a file that contains the information of the colours that are possible to achieve. Colour matches between different CPs must be tuned using one of the several algorithms available in graphic design. The focus of our work was to evaluate and compare the results of 6 algorithms using the same input for 12 different CPs, using a colour sample of human skin tones, producing a total of 72 colour conversions. The results were treated with focus on (i) calculate a set of quantitative indicators and (ii) perform a set of statistical tests to impart meaning and reliability to the conclusions. Considering as Qualitative Assessment the human sensibility to colour differences, our data shows that the resulting colours can be quite different and some algorithms produce substantial better results.

Keywords: *Colorimetry, Colour Management, Colour Conversion, Skin Tones, CIEDE2000*

INTRODUCTION

The aim of a DCM (Digital Colour Management system) is to ensure the best colour match between colour representations and/or between devices. Nowadays, DCM software is ubiquitous in digital systems in order to enable automatic colour conversions and colour representations. We measured, compared and evaluated the performance of the most common algorithms used in the DCM colour transforms. We used as sample a set of colours that are unquestionably important, a set representative of the variety of human skin tones. Trough the CIEDE2000 colour difference formula, we considered as Qualitative Assessment the human sensibility to colour differences.

THEORY

In a DCM system, colour conversions are enabled by small digital files, the Colour Profiles. They are similar to a colour catalog, encompassing the information about the colours that are possible to reproduce or to achieve in a specific device or colour space. The DCM controls the Colour Profiles with a set of commands, the tuning of the colour transformation. In these commands there are different algorithms and options to calculate the best resulting colours.

In a brief and simpler explanation, the DCM software is the macro system, the Colour Profiles are similar to libraries that contain the colours possible to achieve and the algorithms are the rules to transform colours, algorithms that can be – or should be – fine tuned by a user. These algorithms are called CMP, *Colour Mapping Algorithms*, (Fairchild 2013) and in each colour transform only one algorithm can be used. The reason for the existence of many CMP is that none of them offers optimal quality in colour transformations (Green 2010).

In graphic design, the Colour Profiles are under supervision of the ICC, *International Colour Consortium* (Anon n.d.), entity that defines and controls the quality of each Colour Profile available. As so, each ICC Colour Profile, *ICC_CP*, has quality control. For the ICC_CP are established four CMP to calculate the colour transforms (Green 2010): Perceptual, Saturation, Relative Colorimetric and Absolute Colorimetric – this last one is only used for technical purposes like colorimetric measurements (ICC 2010), and only the first tree CMPs are considered usable.

An important fine tune can be used to modify the behavior of each CMP, called BPC, *Black Point Compensation*. BPC was created by the Adobe Corporation (Adobe 2006) and the mission of the BPC is to repurpose the darkest colours in the original to the best possible match in the destiny using a non-linear approach (Brinkmann 2001), trying to translate to the new set of colours the sensation produced by the darkest original colour (Homann, 2010). In 2013 the ICC organization has reviewed and optimized the BPC algorithm (Saguer 2013) and in 2015 the normative "ISO 18619: 2015" started to regulate the implementation of the BPC in ICC profiles.

In sum, in a DCM system used in graphic design, the combination of the two main options – CMP and BPC – can produce at least six different results for the same colour transform, i.e., for the same input there are six possible outputs, even in the simplest operations, such as sending a graphic design project to a printer.

Since none of the CMPs is considered sufficiently effective to be considered standard, the solution was to deliver the responsibility for the choice of the best colour transform in the user. However, information and experiences with CMPs that could be guidance to a user are scarce. As so, we considered pertinent the evaluation of CMPs performance when dealing with a set of important colours that are the focus of this work, a sample representative of the universality of human skin tones.

EXPERIMENTAL

We evaluated the differences between the CMPs and the BPC option by comparing the results of colour transformation using 12 CMYK Profiles from the ICC organization. Since there are 6 possible CMPs outputs, the total results evaluated was 72 colour conversions. The colour sample is a set of skin tones representative of the human diversity. Colour analysis was done by DeltaE (dE) calculation for a reference standard JND – *Just Noticeable Difference* used in the printing industry, the CIEDE2000, using the software “PatchTool” from “BabelColour” (Anon n.d.). The results were systematized and treated quantitatively. This treatment focus on (i) calculate a set of quantitative indicators and (ii) performing a set of statistical tests in order to impart meaning and guarantee the reliability statistical conclusions obtained.

a) Sample: 144 skin tones and target Kodak 6033 PKR

The sample of skin tones was in “sRGB IEC61966-2.1” colour space and contains 156 colours: 12 achromatic tones and 144 skin tones, of which 110 are the palette of the brand "Pantone Skintone ™" and 34 belong to the digital palette "Skintone" included the applications of the brand Adobe Systems. For analysis of qualitative efficiency in the colour conversion to (i) force the algorithms to deal with a wider range of colour and to (ii) recreate similar conditions to a digital workflow, we used an additional target (left side) representing people with different skin tones.

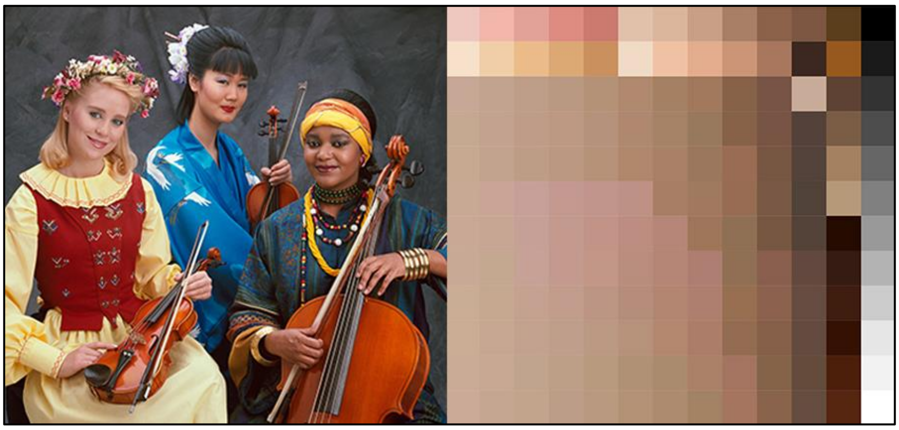

Figure 1: Colour Sample.

b) Establishing a Colour Difference as Qualitative Assessment

The evaluation of the difference between two sensations is considered a qualitative assessment and needs a scale that quantifies the differences between perceptions. This type of metric is called JND, *Just Noticeable Difference*. However, is not possible to argue that the phenomenon of colour perception is only physiological; colours are cognitive and psychological complexes and it is not plausible to assume a principle of neutrality in the evaluation of colour or of their differences (Brinkmann 2001).

To calculate the colour dissimilarity there are several possible equations and the result is represented as "Delta E", "ΔE" or "dE" (Hunt & Pointer 2011). The CIEDE2000 formula is the most recently recommended for the printing industry. Although since its launch in 2001 continues to receive constant refinements (Sharma 2005) up to the latest colour appearance model CIECAM02 (Tastl et al. 2005), the CIEDE2000 intended to be adopted as a scientific standard.

For the standard difference in value, experts consider the limit JND<1 too low, so it is plausible to consider the value JND<2 as appropriate (Foster et al. 2005; Roehrig et al. 2010). This largest value can encompass the *Commercial Acceptability* (Berns 2000), related to mass production quality oscillation. Our choice for this higher value is similar to a tolerance for the industrial process where some deviation of colour is accepted. Briefly, with the adoption of this higher value we consider that the observer is not a colour expert.

The qualitative JND DeltaE (dE) metric is as follows: dE<1 is the optimal range, 1<dE<2 are acceptable and the dE>2 is a noticeable difference.

c) Calculations and Approach to Results

We used a set of statistical tests to extrapolate the relationships between data algorithms, ensuring statistical significance to the set of conclusions from experiments:

• Test *Pearson Correlation Coefficient* to evaluate linear relations between batches;
• Test *Standard Deviation and Coefficient of Variation* to evaluate data dispersion;
• Test *Null Hypothesis Wilcoxon* to evaluate the independence of groups of data;
• Test *Null Hypothesis ANOVA* to estimate the representability of closely mean values.

RESULTS AND DISCUSSION

We consider that all the colours should be below dE 2 to validate the performance of each algorithm. However, facing the unexpected low conformity in the results achieved, we decided to present additional indicators in the "Table 1" (following page). By analysis of the indicators we highlight the following:

- "ALL Indicators" – In compliance with all indicators in dE<2 there are only 16 outputs representing only 22.2% of the 72 possible outputs.
- "minus MAX" – removing the 3 colours with higher dE, the overall performance improves, increasing from 22,2% to 55.5%.
- "only MEDIA" – Making an average of each batch, the results improve to 80,5%.
- "only best 90" – Making an average of each batch and excluding the worst 16 colours, the results improve from 80,5% to 83,3%.
- "major dE" – The highest deviation achieved in each CMP. Some values are extraordinary higher; just for reference, a value of dE 30 is similar to a difference between beach sand and a dark brown.

Table 1 **– Quantity of Profiles with the indicators in accordance with dE<2**

OUTPUT (maximum is 12)	ALL indicators	minus MAX	only MEDIA	only BEST 90	Major dE
Perceptual	5	10	12	12	5,3
Perceptual + bpc	6	9	12	12	5,3
Relative Colorimetric	0	1	8	10	31,5
R. Colorimetric + bpc	4	8	12	12	11
Saturation	0	6	7	7	29
Saturation + bpc	1	6	7	7	30,5
Only Algorithms	5	17	27	29	
Only Algorithms+bpc	11	23	31	31	
Total quantity (in 72)	16	40	58	60	
Total in %	22,2%	55,5%	80,5%	83,3%	

The use of the option BPC improves the performance of the CMPs. Overall, the best qualitative performance was achieved by the CMP Perceptual with the option BPC active, although the results were in conformity only in 50% of the Colour Profiles.

CONCLUSION

In some algorithms, the low conformity was very high and some colours in the sample – not always the same colours – had extraordinary higher differences between batches and were notoriously different from the original input.

Overall, the best performance was the Colour Mapping Algorithm Perceptual, with the option Black Point Compensation activated, but delivered good results only in six of the twelve ICC Colour Profiles evaluated.

In a colour conversion, the remap of chromatic colours tends to have higher differences in the more vivid colours (Chen & Beghdadi 2011), colours with higher saturation. Dull tones and slightly intense colours, like autumn tones and soil colours, that are quite similar to the human skin tones spectrum (Reeder et al. 2014), don't have higher levels of saturation. In this sense, the achieved results were surprising, because our data showed a general low conformity in tones not highly saturated, moreover when considering that the Qualitative Assessment was established with some tolerance, emulating the observer as a non colour expert.

In sum, the current Digital Colour Management system used in graphic design delivers to a user the responsibility of fine tune colour conversions. However, this technology, even fine tuned, appears to have an overall irregular and low performance when dealing with human skin colours. Schildt, G. 1997. *Alvar Aalto in his own words*. Keuruu: Otava publishing Company Ltd.

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Colour rendering of window glazing

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ABSTRACT
This paper proposes a new method for evaluation of colour rendering of window glazing. Unlike the CIE colour rendering index which is expressed by one number, the proposed method follows the idea originally proposed by Lynes (2015) of using three colour dimensions: Hue, Chroma and Value. The algorithms included in Lynes method were tested by the authors using some types of modern glazing having strong colour tinge, e.g. the electrochromic one. We found that his algorithms gives reasonable results for glazing having moderate shade under overcast sky, but significant errors can be expected in the case of modern glazing. A modified method was then proposed and tested on the same glazing types. It gives information about expected colour changes in Hue, Chroma and Value based on the total and spectral transmittance of glazing.

Keywords: *Colour Rendering, Window Glazing, Colour Perception.*

INTRODUCTION

The CIE Colour Rendering Index (CRI), defined in CIE 13.3-1995, especially the general colour rendering index R_a, is widely used by the lighting industry both, in standards and in lighting design practice. However, limitations of the CRI, especially for solid-state light sources, generated the need for developing of measure that is more precise, namely colour fidelity index R_f (Yaguchi et al., 2017). Still, the R_f, as well as R_a does not address perception related colour quality measures beyond overall fidelity. The main difference between the R_a and R_f is precision, while calculation of R_a is based on 8 samples, R_f is based on 99.

For architects and interior architects working with coloration of surfaces the question addressing the way light influence colour appearance is much wider. In addition to the general information about the change, it is important to know if the surface colour appears as lighter or darker **Value**, more or less coloured **Chroma**, and if it is possible to observe changes in **Hue**. Just, the usage of the three colour dimensions is necessary to describe the colour change in a useful way.

Glazing is a layer of transparent material positioned between sky and sun, and the interior; it functions as a colour filter. For evaluation of CRI a light source is needed. One possibility is to use the standard daylight illuminant D65 together with glazing. However, contrary to electric light sources, daylight is extremely dynamic. Exclusive use of the D65 do not articulates those unpredictable dynamic changes as it represents only one of possible variations of daylight. Interesting question is if it is possible to develop a measure of colour rendering of glazing based only on the glazing specific data, that is, spectral transmittance and/or total light transmittance. This idea was originally suggested by Lynes (Lynes, 2015) who proposed also a few algorithms for calculation of shift in Hue, Chroma and Value.

The modern glass technology, as electrochromic (EC), photochromic (PC) or electro- tropic (ET) glass puts us in front of new challenges. Their spectral transmittance (Figure 1) differ from a clear glazing. The electrochromic glass, for example, has extreme variations with high values at a part of wavelength range and values close to zero for another range. Will the Lynes method give trustworthy results for such glazings? If not fully, how a new method of Colour rendering of window glass could look like?

The experiment heading to answer the first question was carried out at the artificial sky the Norwegian University of Science and Technology (Arbab and Matusiak, 2018, Matusiak and Arnesen, 2005, Matusiak and Braczkowski, 2014). The procedure will be shortly described in the following paragraph. The findings indicated that the Lynes method is most reliable for glass with modest colour tint combined with 6500K.

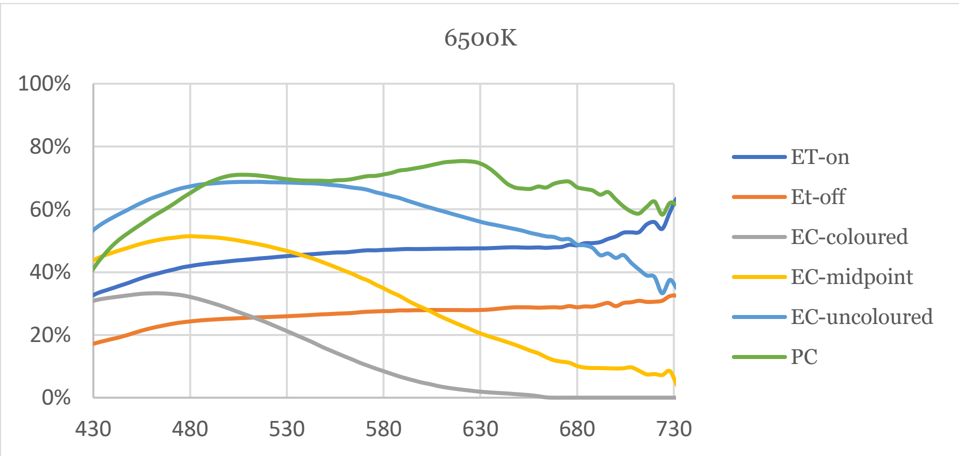

Figure 1. Spectral transmittance of glazing.

EXPERIMENTAL

The experiment was carried out in a grey box representing a room 3m x 3m x 3m in the scale 1:5 that was placed under artificial sky in Daylight laboratory at NTNU. The artificial sky can mimic a range of colour temperatures, in this experiment the following were used: 2700K, 6500K and 8000K. To enable both stable and comfortable illumination, the illuminance level under artificial sky was adjusted to 50% of the maximum power giving the illuminance in the range 129– 700 lx on the floor of the model. Eight samples from Munsell system which is commonly used by CIE were placed inside the grey box on the floor close to the window opening where the light level is even over a large area. The colorimetric measurements of these samples were done with different glazing types in combination with different CCTs. The measurements were carried out with spectroradiometer SpectraScan PR-655 from the exact eye position (Figure 2)

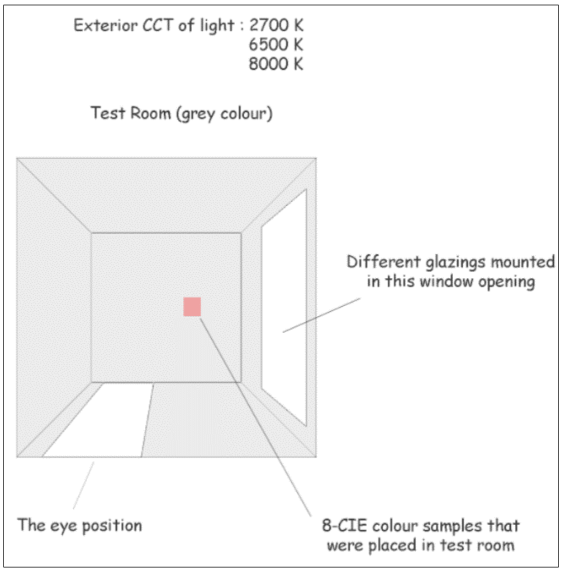

Figure 2. Top view of experimental set-up.

THEORY

The measures of colour shift for the three colour dimensions according to Lynes are shown in Table 1.

Colour dimension	Description	Calculation algorithms
Chroma	Saturation, vividness, purity of colours	Gamut area at the CIE u,v - graph
Hue	The subjectively dominant part of the spectrum	Hue Conservation Index HCI=1- $\frac{Tc-Td}{Ta+Tb}$ where: Ta = Transmittance at 525 nm Tb = Transmittance at 700 nm Tc = Transmittance at peak Td = Transmittance at trough
Value	Lightness, Reflectance	Transmittance ratio = minimum/maximum wavelength transmittance

Table 1. Summary of Lynes method.

We agree with Lynes stating that "the gamut area is helpful to evaluate the amount of colours that can be reproduced" (Lynes, 2015). A window glass with a smaller gamut area, for example electrochromic one (EC), tends to have bigger chroma distortions, i.e. smaller number of colours can be perceived. On the other hand, a large gamut area contributes to large number of colours and makes it easier to discriminate the surface colours. It helps also for visual clarity. It makes sense that larger gamut area would be preferred by users because surface colours will look more vivid. It was exactly what we found in previous experiments with participants (Arbab et al., 2018).

Therefore, we adopt, after Lynes, the gamut area as a measure for Chroma in the new method, see Figure 3.

As the u' v' graph is characterized by uniformity, the distance between two points at this graph should be a good measure of the Hue difference, e.g. a measure of colour shift caused by the glazing. A new measure of colour rendering method for hue could be based on the calculation of the distance between the point at the u'v' representing a sample illuminated directly by a given light source (CCT) and the point representing the same colour sample illuminated by the same light source after passing through the glazing under consideration. The EC is the most extreme example we know about regarding colour distortion, the maximum distance of 0.15 was found for the red sample (Munsell 7,5 R 6/4) and the average distance for the eight colour samples illuminated by light passing through EC, was 0.10 (XXXXXXXXXXX.

For the Value the best measure among the alternatives we considered was the median transmittance. To avoid typical measurement errors at both ends of the spectrum interval we limited the range to 430nm-730nm. In this way a strong impact of the extreme low or high values is avoided because they are never at the middle. The median transmittance is remarkable for this purpose, as the errors in readings at the ends will not have any impact.

RESULTS AND DISCUSSION

The improved colour rendering method is summarized in Table 2.

Colour dimension	Calculation method	No glass	clear glass	Electro-chromic glass
Chroma	Gamut area at the CIE u'v'	0.0084	0.0076	0.0023
Hue	Distances between no-glass and glass points at the CIE u'v'	0.00	0.02	0.06-0.15
	average		0.2	0.10
Value	median transmittance of glazing	0.00	0.57	0.08

Table 2. The new colour rendering method.

The colour rendering of glazing is proposed to be developed in the following way:

<u>Chroma</u>

1. Calculate or measure chromaticity of the 8 CIE colour samples using the black body illuminator 6500K, mark them at u' v' diagram (red line on Figure 3)
2. Calculate the gamut area of the "no glazing" case
3. Calculate or measure the coordinates of the 8 CIE samples illuminated by the black body illuminator passing through the glazing under consideration (e.g. yellow line for EC-coloured-6500K and green for clear glass)
4. Calculate the shifted gamut area, i.e. of the samples illuminated by 6500K black body light passing through the glazing (e.g. the area of the yellow figure for the EC and green for clear glass)
5. Calculate the relation between the shifted gamut area and the original one (e.g. for the EC the calculation will be: 0.0023/0.0084=0.27 while for the clear glass: 0.0076/0.0084=<u>0.90</u>

Hue

1. Calculate the distance between points representing a colour sample at the u'v' diagram for 6500K and 6500K+glass for each of the 8 colour samples. It will give the information about the size of the of hue change for the 8 colours. Additionally, the direction of the shift is clearly visible at the graph (Figure 3).
2. Calculate Average Colour Shift Distance (ACSD), which may give the overall understanding of the shift. As the most extreme colour shift we know about is <u>0.10</u> for EC, it may function as a maximum value. Other glass types may be compared to it (e.g. ACSD for clear glass 0.02 is 20% of the ACSD for EC 0.10)

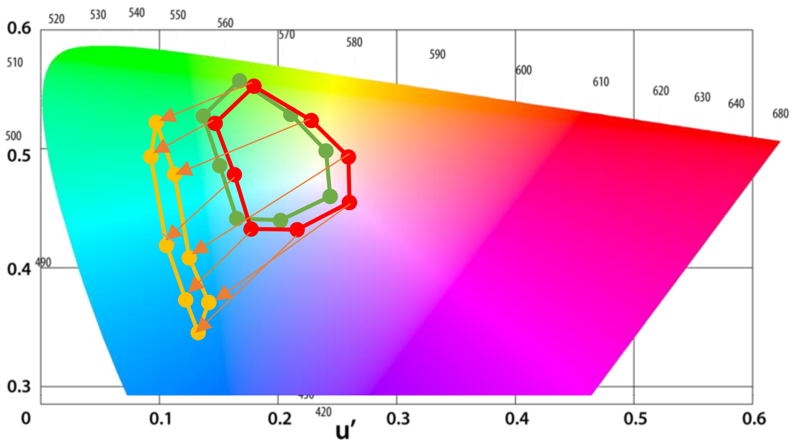

Figure 3. Gamut areas and colour shifts; red-no glass; green-clear glass, yellow-EC.

Value

1. Calculate the Median Transmittance for the glazing from the spectral transmittance data. Assuming 80% median transmittance as a theoretical maximum of any glazing, the median transmittance for clear glass will be 57/80, i.e. <u>71%</u> and for EC 08/80, i.e. only 10% (Arbab and Matusiak, 2018).
2. Calculate luminance ratio Y with the formula: $Y=L/L_w$ where L is the luminance of a sample and L_w is the luminance of a white sample illuminated by a constant illumination (electrical light) for two conditions: with and without glazing. For example: Y(no glass)= L/L_w, and Y(EC)= $0.1*L/L_w$
3. Using formula: $V_Y = 40(Y - 0.43)^{0.51}/[(Y-0.43)^{0.51}+31.75]$ (Valberg, 2007), calculate Value V_Y for no glass and the glass under consideration as well as the difference between them.

CONCLUSION

As the proposed method is based only on the usage of the technical specification of glass, i.e. the total transmittance and the spectral transmittance SPD, and the limited number of 8 CIE samples, it should be considerably easy to use it, both by the companies developing new glazing types and by practitioners planning to apply glazing in buildings.

The colour shift in terms of Hue is well understandable, see Figure 3, as it is easy to find out how each of colour samples will change its appearance regarding both direction and strength of the shift. The changes of Hue, Chroma and Value can be specified with numbers, relatively to the theoretical maximum values proposed in the paper and marked with underline font.

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Colour in Arts and Design

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The unexpected meeting: How to create unique colour choices for products

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ABSTRACT
The goal of this artistic development work was to deepen the knowledge in the area of colouring for products. Strategies and choices of colour are often made without using design methods or engaging the user, thus not making much use of all the developments in user-centred methodology otherwise influencing many areas of design. In this series of experiments I performed, two different issues were central. The first challenge was to look into creative methods for making colour suggestions. In order to deepen the understanding of process and method, the second issue investigated was to perform colour studies where chance played a central role. The methods developed were evaluated through exercises in teaching "colour on form" as a subject for BFA students in industrial design. In this paper, I report on these experiments, the methods developed, the output they resulted in, as well as reflecting on their potential relevance in design education.

Keywords: *Colour for products, education, norm critic, design, social norm*

INTRODUCTION

At UID the approach is to put the user first regarding all parts of the project from methods to aesthetics. We have a strong collaboration with the industry engaging all stake holders. Testing ideas and doing experiments is an important step in the students learning process to explore the possibilities of design. As I work part time as a lecturer at UID and part time as a professional industrial designer I have the advantage to bridge over my experience from industry to my role as a teacher in design.

Our perception and ways to interpret colour are influenced by many factors, including both more slowly changing ones such as experience and social norms, as well as short-lived trends.From my experience as a designer I have found that colour expertise from material suppliers and trend institutions are often regarded as truth and many companies rely on their forecasts. Further, the strategies and choices of colour are often made without using design methods or engaging the user, thus not making much use of all the developments in user-centred methodology otherwise influencing many areas of design. This was a challenge for me to implement this in the education at UID as a lecturer in industrial design.

THEORY

In this series of experiments I performed, two different issues were central. The first challenge was to look into creative methods for making colour suggestions for a product/form regardless of trends and prejudice, thus looking for structured ways of challenging conventional thinking by means of a norm critical approach. Here, the starting point was to express the function and to meet the users' expectations. In order to deepen the understanding of process and method, the second issue investigated was to perform colour studies where chance played a central role, thus using the accidental and unexpected as a still structured way to challenge norms and preconceptions.

The overall objective was to see if these two different approaches would converge in some way by testing new strategies to manage colour and form. Finally, the methods developed were evaluated through exercises in teaching "*colour on form"* as a subject for BFA students in industrial design at UID.

EXPERIMENTAL

Seeking to know how colouring works on three dimension objects I created the form ghost, a blank 3-dimensional form to apply colour on. I chose to build a simple form from a selection of standard blocks for hobby purpose. The form ghost is an object that can be associated with a function or an identity but with no immediate likeness with any brand or exciting product. For example could a simple straight rectangular form symbolize a handle or a small spherical piece applied to a surface represent a button. The building blocks were put together with an obvious expression and low complexity. The purpose is to put focus on the colouring and not on the form. The form ghost is not designed in the way that it's worked in detail. Simply it should represent a form with a function, an abstraction of an object. The purpose is to study colour on a three-dimensional form to see how light and shadow affect the hue.

My process started with sketching in Illustrator creating ideas of how to combine and apply the colour on the form ghost. The digital tool provided a variety of ways to conveniently explore and evaluate colour. I could then create a palette guiding me when painting the form ghost. The process then moved from the digital context to physical paint. The hues were made with black, white and the primary colours blue, red and yellow in a warm and a cold version. Ultramarine, Prussian blue, Vermillion, Crimson, Cadmium yellow and Lemon yellow.

In the first experiment, randomly picked colours, I flipped a dice to select colours to work with. Secondly, I chose to challenge myself breaking the rules of harmony picking colour combination that clashed the most. The third task was to enable chance by counting the number of colours mentioned in three classic works of literature visualizing each novels most mentioned colours. In the last of my experiments I used an inspirational picture from my files and translated the colours in the photo directly to a form ghost.

All the exercises were performed with the intention of putting me in a challenging position giving me unexpected colour choices for me to refine. I set up questions for making an evaluation of the different tasks. The questions demanded evident answers to facilitate the comparison between them and to evaluate how valuable they could be in teaching.

IMPLEMENTATION IN EDUCATION

Taking this further in to education my decision was to use the creative method working with the form ghost. The task would be to express the three characteristics of the object. The characteristics are the product identity through the semiotic of the form, the users emotional expectations and an imagined context.

I had the opportunity 2015 - 2017 to test the method working on the form ghost with BFA1 students in industrial design. The assignment was formulated like this: "*Build a form ghost that represent a function, have an intended recipient and a context that you decide. Construction can consist of two maximum three form elements + possibly a detail. Build the shape and paint it with your chosen colours.*

Work digitally and print your colour proposal and mood board. The proposal shall verify the three key words you have chosen for the product stated by the following bullet points:

- *Product identity - What characteristics do the product express?*
- *Receiver - What are the recipients expectations?*
- *Context – What context is it?"*

Figure 1: BFA1 2014 at UID working on the assignment creating colour applied on form ghosts.

RESULTS AND DISCUSSION

With a practical view point evaluating this project I understood that getting hands-on and mixing colour enhance the quality of the work though it's more time consuming. Like my student I tend to spend more time in the digital space since it's time saving and you don't get your hands dirty. Seeing student work hands-on with painting proves that it's also therapeutic and soothing for your mind. I can see they have fun, easily working with flow. It reminds you how design relates to traditional art forms such as sculpture and painting.

In the future I'll consider telling the students to use other primer than white paint for the "form ghosts". White tends to be a chosen proposal but it's hard to tell if that is a result of a conscious decision or just a given factor that they use. The reason I chose white primer was that it's the standard for base coat on wood. My conclusion is that the white surface represent cleanliness, resembles a white canvas that restrain you from painting it over. A better choice for primer would be putty grey because this colour may be looked up on as dirty and less neutral than white.

I have chosen to handle colours on a basic level regardless of opacity, gloss and structure since this would have enhanced the complexity of the study. There is a need to look at how different surfaces, both shallow and dramatic, affect the look of the colour. Adding these dimensions was not included in this project but it is a logical step that can take the experiments further.

From a theoretical aspect a deeper knowledge in colour theory give you tools for experimentation. My insight is that if you know the rules you can break them.

The colouring process is intuitive and at times hard to grasp. It's affected by personal opinions and feelings that can be hard to describe and fit in to a framework. I miss a more profound discussion on colour in the design process. The choice can be presented without deeper explanation and this reveal that colouring is sometimes a process driven by chance.

CONCLUSION

In the area of product colour the influence of trend forecasts has grown stronger. Manufacturers of colour systems present seasonable colour choices to market their products. Material manufacturers such as suppliers of pigments, varnishes and granules present their products with summarized versions of trends that forecast agencies produce. They offer collections and predictions for colour selection that streamline and facilitate the choice of colours for the industry. Because of their assertiveness these general trends are convincing and the risk is that it puts the choice of colour outside the influence of the designer.

Our perception and ways to interpret colour is influenced by experience, social norms and short-lived trends. One goal was to free myself from conventional thinking and have a norm critical approach in this project. The colouring process is a valuable tool for the industrial designer. My ambition was to find a way to look at colouring in this field since in my research I mainly found strategies regarding architecture, graphic design and fashion.

The idea of working with chance as a factor for the colour choice wasn't too distant from reality. When working with a company there are often given conditions stated by the company like a corporate colour, industry standard or a colour preference formed by a former design. In this way you are not free to work with whatever hue you would like from the beginning. The colours stated in the function list are a preference you have to consider and sometimes have to stick to. In that sense it's not so different from picking a random colour that you have to work with.

Looking back on my ADW I can see that I've tried to explore two different areas in the process of colouring. One was to focus on the object, creating colours from functional and communicative values to meet user demands. This I practised with my students. The other part was to find creative ways in the process released from the influence of trends that affect the colour choice to create an unique result. Though I had the ambition I could not make these different tactics of working with colour and design converge.

In the design process colour should also be methodological treated as a material and be questioned as any other component of a product both regarding its emotional and economical sustainability. Trend forecasting is used as a marketing tool aiming to sell new product and keeping up the pace of consumption. In the sustainable society we may not need a constant delivery of colour trends. The process of colouring is a powerful tool for the designer. If we practice, explore methods and gain more knowledge we can use it more consciously.

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Web source: http://ncscolour.com/about-us/how-the-ncs-system-works/

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colour & human comfort

Lisbon, a colour experience from sketch to illustration

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ABSTRACT

The paper reports a colour experience that takes place in Lisbon by drawing some chosen urban landscape along a path. The colour perception was registered, using watercolour or coloured pencils, in order to identify a predominant palette as a component of each place pregnancy. The full experience achieves at least three sorts of colour expertise: The first is the consciousness of colour role as a component of a place identity; the second is the use of colour to improve drawing legibility; and the last is about decomposing colour as way to understand the chromatic harmony. Furthermore, the experience can be performed as a didactic dispositive in order to arouse colour sensibility, by other sketches, at other cities.

Keywords: *Sketch; Illustration; Colour identity; Urban colour palette; Colour atmospheres*

INTRODUCTION

Urban landscapes are often represented with an almost grey palette. In fact, skylines, building shapes and shadows can be drawn with just one pen, getting satisfactory result. The defence of an adequate representation done by line, being colour an "inessential adjunct to form", as John Gage (1997, p.117) reports[1], was an Ancient notion. This idea returns at Renaissance and along the time, remarking the seriousness of draw in representation at arts academy. Besides, in the history of image reproduction, the domain of colour followed that of the monochromatic techniques since engraving until photography[2].

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[1] See "Disegno versus coloure". In: Gage, J. 1997. *Colour and Culture: Practice and Meaning from Antiquity to Abstraction. London: Thames and Hudson,* pp. 117-138.

[2] As J. Gage point: "*We're all used to experiencing the world as black-and-white images in photography and film: these images are the successors of monochromatic engravings first produced in the fifteenth century that until the nineteenth we usually regarded as adequate even for the reproduction of paintings - and by painters themselves.*", *Op. cit.*, p. 117.

Nowadays[3], it is not difficult to reproduce full colour images. The landscape of each site and each city leads the observer to a different range of colour experience. Even if digital photography had become so usual, some people prefer to keep their cities memory in a sketch book. What they keep is more than a landscape in two-dimensional support; it is an experience in time.

In 2010, the following event took place: seven artists drawn respectively one of the seven hills of Lisbon. The published work had an essay by João Seixas and the graphic artists were E. Salavisa, F. Leal de Faria, J. Catarino, J. Louro, P. Cabral, P. Fernandes and R. Câmara[4]. In July 2011, the II Urban Sketchers Symposium, took place at Lisbon, too. The book published *Urban Sketchers in Lisbon: drawing the city* (2012), shows a large range of Lisbon landscapes interpretations, by several sketchers: from black and white pen and ink drawing, to watercolour painting.

Even before, Lisbon light and colour atmosphere[5] has been an issue for many artists and works - as the XXth Lisbon painter C. Botelho (1899-1982)[6]; the movie *Dans la Ville Blanche* (Tanner, 1983)[7] ; the writer J.Cardoso Pires (1925-1998), who alerts to "the impetuosity of a [Lisbon] light that at the same local, at the same instant and in the same colour never repeats itself"[8] – among many other authors and works.

This paper reports the dialog between two ways[9] of seeing the same city. One, is a one year visitor perspective and the other is a native that has a life time memory. We joined our sensibilities and some concepts to explain a particular colour experience in Lisbon. This presentation goal is to share an experience of colour perception and notation. Instead of looking for a colour identity to the city of Lisbon, the goal is to point situations where the colour causes a visual impact. To experience it, we choose, not a place or building, but a path where we pointed and drawn some places. Few of them were studied, in which colour has an important role for each of these places being memorable. At the end we will choose, at least, one to perform an illustration.

THEORY

John Gage (1999, p.11) refers to "subjective element in visual experience and the objective quantifiable stimuli" and also "the subjective outcome of an objective process of stimulation"[10] such dichotomies feeds investigations in both art and science. Whereas the large number of reviews of colour theory[11], we consider the resume published by Lenclos[12], for the sake of proximity approach with the subject matter. We emphasize their two subjects, colour and city. Although it refers to French villages, the authors developed a methodology that can be exemplar

[3] However, the use of pigments and the development of natural binders is another side of this ancestral history that goes along arts until contemporary synthetic inks. Also, it is not possible here to resume the optics knowledge heritage as the improvement of technology devices have together, along the lasts two centuries, changed progressively the way we are used make and copy images.

[4] Salavisa, E. (coord.) 2010. *Diário de Viagem em Lisboa – Sete Colinas, Sete Desenhadores*. Lisboa: Quimera.

[5] See: A cor de Lisboa.2012.*Arca de Darwin*. December 28, 2012 [Online].[Accessed 15 June 2018].Available from www.arcadedarwin.com/

[6] See: Silva, A.Sena da., Botelho, M., Oliveira, 1989. *Botelho.* Lisboa: Fundação Calouste Gulbenkian- Centro de Arte Moderna [cat.].

[7] *Dans la Ville Blanche*,1983. [Film]. Alain Tanner.dir. Switzerland: Laurent Ulher.

[8] Pires, J. C.1997. *Lisboa, Livro de Bordo. Vozes, Olhares, Memorações.* Lisboa: Publicações D. Quixote.

[9] Both the authors are Drawing Assistant Professors, respectively at Universidade Federal do Ceará, Brasil and at Faculdade de Arquitetura da Universidade de Lisboa, Portugal.

[10] In: Gage, J. 1999. *Colour and Meaning: Art Science and Symbolism.* London: Thames and Hudson, p.11.

[11] So, to follow this paper that is about an experience we'll need a basic knowledge of colour theory, like primary pigment colour composition, the position of hues at colour wheel, concepts of complementary colour, harmony and contrast, as well as colour value and saturation. Also the relationship between colour, form and size.

[12] See the topic: "Urban Landscape". In: Lenclos, J.P. and Lenclos, D., 1990. *Coleurs de La France: Geographie de la Couleur*. Paris :Editions du Moniteur, pp. 11-20.

for other urban colour studies[13]. From Lenclos (1990, p.11), we consider also the concept “permanent colour” as the colours whose aspects are more durable, as mineral elements and building materials (Lenclos and Lenclos, 1990, pp. 52-53). From Lenclos, it was observed also, the method and the link with the fundaments of colour theory.

As a general concept, important for us, we resume the idea of "visual mark" explained by Kevin Lynch[14] and the specific local visual marks, as those that can be seen in close proximity. These references helped to outline a script to experience: By understanding the path circumstances; by identifying *visual marks*; by recording the colours palette of each place and landscape notation in the sketch book; and by experiencing ways to represent the coloured landscape.

EXPERIMENTAL

The visitor studied, a day before the first and mixed two routes[15].The initial propose was to walk to Baixa, following visual tracks to not get lost, and remember how to come back. In the way, the places that cause a particular impression were drawn. One of them was painted, by memory, in order to remark their chromatic composition. It was autumn, a few weeks after arriving in Lisbon. This route has become frequent in the following months.

Considering the influence in colour perception by season’s changes, along this time some draws and photos were done at different months. Some descents, ascents and sketches after, when the winter was gone the visitor tried to repeat the experience in a more systematic way.

First step was to understand the path in the city context. The experience took place along a route that connects *Miradouro da Graça* to the *Praça do Comércio*. It is a sinuous line from the hill to the river. Also, in the way, the visitor can devise some historical marks, as Castelo de São Jorge , the Catedral, both before the XI century, until the Baixa Pombalina, from XVIII century. As an evidence of the overlay of time, there are too some Vilas from the beginning of industrial age, with its characteristic tiles. Also, the path keeps with a part of the 28 rail, and is a popular tourist tour.

Second step was to identify *visual marks* by the chosen path. This process is almost intuitive, since they are the ones that catch attention by the senses. Contrasts of size, colour, and others aspects like the style, can help a place relevance. Even though there can be differences between one or other way to perceive. After identifying the visual marks those that caused a colour memory were redrawn, *Largo da Graça-Vila Sousa*, Portas do Sol - *Museu das Artes Decorativas* and *Praça do Comércio*, in the end.

Next steps were to record palette’s colours of each chosen place, while drawing and colouring landscapes in sketch book. We consider also practical aspects as weight and medium domain, to make a drawing trek. The aim is to perform a coloured sketch, fast and few colours. Materials used were water soluble coloured pencil and watercolour set. The pencil was used also dry, just to draw. One of these pictures was prepared to be reproduced as an illustration, by coping different layers of colours together.

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[13] We did not apply exactly the same methodology, but it is similar in some points like the colour landscape notation as sketch or, as Lesclos name: “*croquis colouré de situation*”. In: Lesclos. *Op. cit*., p. 67.

[14] *The image of the city* was first published in the sixties; See the concept ‘visual marks’ (*pontos marcantes*) p. 59. In: Linch, K. 2003.A imagem da Cidade. Lisboa: Edições 70, p. 59.

[15] The path chosen has coincident passages with the ones suggested by Anysio Franco on his book. Mostly it follows the last one, but in a opposite direction, and finishes in Praça do Comércio. See : Franco, A. 2016. *Caminhar por Lisboa*. Porto: Porto Editora, pp.148-171. After we consider extend the experience to achieve the Miradouro S. Pedro de Alcantara, to contemplate the valley and see the different colour layers of the urban landscape and their combination. BeforeAnísio Franco and his proposals to walk and to uncover Lisbon (based in his heritage but also in his human landscape), it must be pointed the already cited path drawings in Lisbon (Salavisa, 2010).

Figure 1: Colour palette studies, local sketches, coloured pencil and water colour.

Figure 2: Minimal palete studies for illustration, coloured pencil.

RESULTS AND DISCUSSION

At Largo da Graça - *Vila Sousa* tiled building is a strong visual mark, with five floors and twelve openings by each one. Blue-green tiles with their geometric decoration (XX Century, end) contrast with roof in orange clay tiles and with other buildings, as Graça Convent and Church with their white stones and light exterior plaster. More distant, trees dialog with Vila Sousa colour facade, oscillating between green or blue, also always depending from light reverberation that whose quality (throught days and seasons) realizes on the glazed tiles surfaces.

At *Portas do Sol*, the first colour stain is dark red – along a wide facade making a corner from Fundação Museu R. Espírito Santo Silva, with his baroque portal. This colour (between almagre and iron oxid, in Portugal sometimes called 'sangue de boi') is warm and velvety dressing the corner, softening its hard angularity; the dialectic by light (and position) is strong: this colour plays with belvedere over Alfama (with its labyrinthine texture) and river, emphasizing river brightness or in extending his leaded colour in cloudy days. In what concerns position, this colour emblematizes an urbanistic theatrical and local surprise effect, as a landing that links a path, from Graça above, with another under, from Baixa.

At Baixa, the *Praça do Comércio*, as a big open scene stage for Tagus and south, incarnates a rhetoric form and a bright (and illuminist) idea of yellow (from ochre). The central equestrian brass statue of King D. José performs the quality and quantity of local light and chroma: the brass colour surpasses itself and becomes a golden blue - by light, surrounding and Atlantic breeze. The luminosity is always strong, even in misty days. The clear stone of Lisbon joins with the yellow, river reflexes and atmospheric perspective colours and high luminosities. The few shadows at Praça perform high contrast dots, especially in the gap of porches. At twilight, the river becomes violet for few minutes, in a brief perception accentuated by the yellow facades surrounding.

CONCLUSION

Drawing and painting in location is an effective way to develop visual attention and accuracy. Our main goal was not to make a naturalist representation, but to figure out a minimal palette to be used as fast as a sketch; reporting the essential mood - with as few colours as possible. The illustration, performed in a craft way of colour separation, by the challenge of making the landscape with less colours, keeping the most significant hue.

If we consider that this experience can be performed as a teaching practice, it can help the students to achieve, at least, three sorts of colour expertise: **1**-The consciousness of the colour as a component of a place identity and what it implies at urban landscape. Further, to consider the colour role to underline the visual marks and to organize the environment observing the balance between contrast and harmony; **2** –The contribution of colour to improve drawing legibility. It means that if the colour has part of the identity of a place it can also identify the picture's place in draw. It is useful even to help the sketcher when he is representing a scene with many details; **3** - The last expertise is about fixing by practice some fundaments of colour theory, as decomposing colour as way to understand the chromatic harmony, for example.

Furthermore, beyond the Lisbon chosen landscapes, the experience itself can be played as a didactic dispositive in order to arouse colour sensibility, by other sketches, at other cities.

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colour & human comfort

What are the Different Purposes of Colours in the Western Visual Arts?

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ABSTRACT
Initially limited to two main colours - red and black, the chromatic palette rapidly grew to a variety of colours, culminating during the Renaissance. New pigments were incorporated with traditional ones and the influence of the Middle East on Venice rapidly spread around Europe, giving to Visual Arts an almost unlimited palette with unlimited possibilities of expression. What is the purpose of colour then?

How does the artist use colour? How does the artist manage the different meanings and the history of a given colour? Purposely breaking the rule of chronology, I will mix artists, eras and medias to highlight the variety and the complexity of colours used in Visual Art.

Keywords: *Visual arts, perception, symbolism, materialization of colours*

INTRODUCTION

Initially limited to three main colours – red, white and black, the chromatic palette rapidly grew to a variety of colours, with a culminating point during the Renaissance. New pigments were incorporated with traditional ones and the influence of the Middle East on Venice rapidly spread around Europe, giving to Visual Arts an almost unlimited palette with unlimited possibilities of expression.

What is the purpose of colour then? We will discuss colour in the occidental visual arts, while trying to move away from the chronological tradition. We will consider colour in the visual arts following three main axes: first, colour as a symbol; secondly, colour as a perception; and finally colour as a material.

THEORY

Throughout Antiquity, as well as during the Middles Ages, there has been an emphasis made on the importance of light in art. We can recall that, during ancient times, the palette was known to be limited to only three colours. Although this theory is today being questioned, we will maintain the idea that the palette was limited during these times for the purpose of our study. In those days, the emphasis was placed on the exaltation of these colours by light, especially thanks to a varnish that gave additional depth to the vivid colours [1]. The importance of light continued all throughout the Middles Ages, a time during which the most significant supports included stained glass and mosaics.

To start one of his studies on colour in art, John Gage, a specialist on the matter, suggested to use as a starting point the belief according to which colour and light are two separate entities, they themselves split into two categories. On the one hand, the material substance that is stable and does not change, and on the other hand the so call "accidental" substance that may change in nature and that does not last in time, for instance, rainbow [2].

To better understand the meaning of colour during the Middles Ages, it is essential to distinguish two definitions of the term "light" in Latin, as it was considered there were two distinct types of lights at that time. The first one is "lux", a light considered to be essential, a light of divine origin, the source of all light, the one that is hidden from our bare eyes. The second one is "lumen", a light that is considered to be sensitive or accidental, a light that is reflected on a surface. Colour is the result of how the "lumen" determines the "lux". Back in the Middles Ages, colour was the essence of a strong symbolism, thus why there was an absolute fascination for translucent materials that seemed to generate light, hence the importance of stained glass in those days.

Colours were used to emphasize, prioritize or even create an opposition. Mixing colours was not well regarded, nor were dye works. Both were considered to be deceitful or even linked to dark magic. Colours were therefore mostly just placed one next to the other without ever mixing together. This is what was found in the art of stained glass for example. The colours were simply placed one next to the other according to a specific pattern that referred to different concepts of religion.

The most important opposition in those days was that between the Cistercian Order and the Cluniac Order. On the one hand, the Cistercians distrusted the use of colours and recommended that places of worship be deprived of colours. To them, colour was considered to be seductive and deceitful, and therefore needed to be banned from any and all places of worship. Furthermore, to them, decorations and colours symbolised vanity and therefore were not compatible with the humble lifestyle Cistercians were meant to live.

On the other hand, the Cluniac Order believed that the Church must show some form of wealth to honour God. Their conception of religion was also different as they considered light to be a symbol of God that, like Him, was present at all times and in all places. Stained glass, to them, was considered to be a path to spiritual enlightenment, turning the coloured light of the basilica into an open door for the "real" light to come in, meaning Christ himself.

During the Renaissance, colours were also used as a symbol. Each colour had a meaning and was both chosen and used for its symbolism. As Pastoureau said, the symbolism of colours changes over time. For example, for the longest period of time, blue was rejected and considered to be the colour of savages, whereas later it turned into one of the most used colours at the end of the 12thcentury when God became the "God of light". Light was then represented with blue colour and blue was then used to represent the sky, clothes, etc. From that moment on, blue became a predominantly used colour [3] [4].

Figure 1: *La vierge et l'enfant entourés d'anges*, Melun Diptych (1450), Jean Fouquet.

During the 20thcentury, we encounter once again the usage of colour as a symbol, Between 1919 and 1923, Kandinsky developed a personal meaning for all colours. Each colour expressed different impressions or emotions. For example, blue was considered to be mystical while green was considered to be peaceful.

The symbolism of colours was also taken up by Yves Klein who used colours as a way of spiritual elevation. When a viewer looks at a religious painting from the Middles Ages, the background is often plain and golden. The eye should only focus on the characters represented and the viewer must feel transcended. Yves Klein reused this concept with his monochromes of gold in order to symbolize the immateriality, to symbolize emptiness.

EXPERIMENTAL

After the Middle Ages, it is not all about the tone anymore. It is more about the perception of colours. Cold colours and warm colours are used to shape the viewers perception.

Modern painters relied on these principles to give the illusion of closeness and distance by using warm colours for closeness and cold colours for distance.

Colours were no longer solely used simply to colour, suggest an information or for their meaning. Colours were now being used for their intrinsic power.

Impressionists used colour to give that illusion of the far and the near in art. They no longer used tones of the same colour, from brighter to darker, to give the illusion of volume, but rather the properties of the one same colour to create an optical effect. Painters played around with the different colours, so that the warm ones seemed to move closer while the cold ones appeared to move further away. But yet what was dark moved further away while what was light appeared to move in closer. The painters then started to leverage on these ideas and began to "manipulate" the human eye.

The properties of colour were even more emphasized by post-impressionism artists to create volume.

These painters no longer used colour to simply give out information or suggest an emotion. Colour was used as a complex tool to manipulate the eye and create new optical illusions. One century earlier, painters would simply have used a darker tint to paint the drapes. As opposed to that, Cezanne here used cold colours, a mix of blue and green, to create the illusion of the drapes.

While colours could be used in paintings to create an illusion of depth, distance and volume, these artists took it one step further by finding a new way to not only disrupt, but even completely manipulate the eye.

In the middle of the 20th century, colour was no longer used to create the idea of volume or for its interpretation, it was used to create an illusion. Colour was then used by artists to disturb the eye.

The term Kinetic Art was first used in 1960 in a museum in Zurich to illustrate the work of Daniel Spoerri. These are works that are "moved or are moved". Artists of the Op Art and of the Kinetic Art willingly disrupted the human eye to create a new feeling. They believed that in order to create a new emotion in the human mind, they had to start by creating a shock in the eye first. The colours here had been used to create an illusion of movement to the eye.

Anish Kapoor also used colour to disturb the eye. No movement here, but a reinterpretation of the daily sights. Anish Kapoor captivates the eye thanks to coloured surfaces that give an illusion of black holes, broken glass or even the illusion of looking into a spoon. The viewer is then lost, seeing his image duplicated or inverted.

Figure 2: Anish Kapoor, *Stave (red),* 2015.

RESULTS AND DISCUSSION

In 1954, Anish Kapoor created "As if to Celebrate, I Discovered a Mountain Blooming with Red", a sculpture made solely of colour pigments. Colour then became a fully-fledged material, back in its raw form: pigment. The pigment here was no longer used together with a diluent to create painting to be applied on a canvas. Pigment became an object, a fully-fledged material. Colour then turned into sculpture in the round. The viewer could then walk around the piece of art and fully appreciate its primary attraction: the colour itself.

From that moment, colour became palpable, considered a material and even an environment all to itself. Some artists even represented colour by light itself as a reference to the origin of the word. In that moment, the viewer no longer walked around the art work but instead walked right into it. It was the art work that then came in to surround the viewer who was immersed into coloured spaces thanks to light. The viewer often had a difficult time finding the limits to the area in which he was. Colour here went beyond the canvas, beyond space itself and travelled to offer a full and complete immersion into it. Thanks to this, new feelings and sensations were created. Colour was then dematerialised and made intangible.

Light was also used to create defined and districted shapes. It’s then that light canvases appeared. Whether in two-dimension or three-dimension, the canvases or sculptures of light delivered the dematerialised colour of the actual material, but stronger and more imposing on the eye of the viewer. The light of the colour brought to the retina of the eye amplifies that colourful feeling.

Some artists even took it one step further and materialized the light spectrum. The etymology of the word “colour” is reused and reclaimed by artists. As colour is light and light is light beam, some artists such as Gabriel Dawe exploited this aspect to turn it into a piece of art. He used threads of colours to materialize the beams. Liz Waist, on her side, represented the light spectrum through installations made of lights.

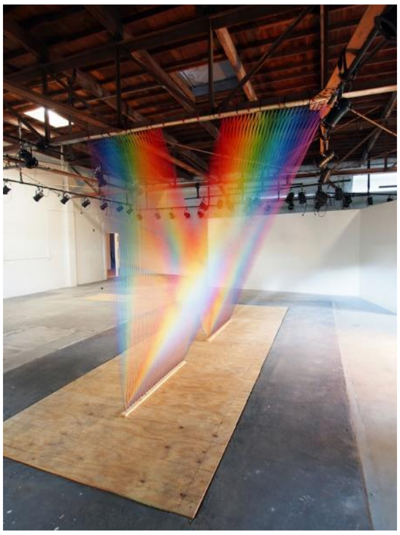

Figure 3: Gabriel Dawe, *Plexus no. 30*,site specific installation at Newark Museu, gütermann thread, painted wood and hooks, 2015.

CONCLUSION

Colours can be used to create a volume, give a meaning, create an impression, disturb the eye but can also open up a whole new universe to us, where colours turn into materials or light. Even if it is difficult to break the chronology when discussing the representation of colour in the occidental visual arts, splitting it into these subcategories allows us to realize the extent of the reasons of using colour. We have seen that colour was used as a symbol by artists of the Middle-Ages and the Renaissance, but in later times as well by artists of modern art such as Kandinsky or Yves Klein. We then saw that colour was used to disturb the perception of the eye, particularly by artists of the Kinetic Art and Op Art, but also by artists who were not part of either group, such as Anish Kapoor who transcribed disruptive elements of the daily life. Finally, we observed how colour was used as a material, whether pigment, thread or light, artists went back to the source of colour, whether etymological or material. From symbolic to material, between traditional and modern, artists continuously find new ways to use and represent colour.

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Colour in Action, participatory paintings on residential facades

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ABSTRACT

After studying artist-, NGO- and civil association-initiated painting interventions in residential building facades, primarily in Buenos Aires, I organized a new painting intervention, ViverCor Corabitando/ LiveColour Colourinhabiting, in Montemor-o-Novo, Portugal. This action research, conducted as part of my PhD in Design, explored forms of participation, and attempted to understand what human needs could be fulfilled by the project in question. Our practice ultimately sought to see a people, their culture and community; in shaping it, we considered the creative participatory process, the legitimacy of the newly painted identities, and possibilities for the participants' personal development. Bringing to fruition a painting project in public space demands dedication and time, raising the question whether such an intervention can be practically effective. We offer answers in the participants' assessments of how they benefited from the project. We hope you will find them inspiring.

Keywords: *Participatory Paintings, Public Space, Human Needs, ViverCor Corabitando*

INTRODUCTION

This paper results from (1) reflection upon and editing of my PhD thesis—"Co-Design of participatory actions in the painting of residential facades: the expression of individual and collective identities shaping public space" (2014), Faculty of Architecture, University of Lisbon, in collaboration with the Faculty of Architecture Design and Urbanism, University of Buenos Aires—into the book "A Cor em Acção/ Colour in Action," and (2) the replication of the action research ViverCor Corabitando/ LiveColour Colourinhabiting at Ruinha, in the context of the post-doc "Co-design in Public Space: The Colour science as a strategy for the development of scientific culture and local sustainability."

The first part of the PhD research was conducted *in situ* between 2009 to 2011, by visiting interventions, and by interviewing experts, artists and promoters: in Tirana, Albania, “Greening and Painting” by Edi Rama (Conte, 2016); in São Paulo, Brazil, "Paredes Pinturas" by Mônica Nador; and in Buenos Aires, Argentina, at six actions: "Calle Lanín;" "Partituras Musicales" by Marino Santa Maria; "Pintar el Once" by La Vereda Civil Association; "La Villa 20 es una Pinturita" by Odisseia 20 Civil Association; "Barracas Pinta Bien" by Más Colour Civil Association, and also "El Abasto y el Fileteado Porteño" promoted by the Association of Residents, Center of Management and Participation No. 2 South (Conte, 2011). With eloquent vision, the case studies in Buenos Aires employed participatory processes to bring new identity-making images to popular (and in some cases, deprived) neighbourhoods by converting “grey” areas into *loci* of identity; they created possibilities to claim participants’ rights and needs, and promoted encounters with public space. But they were not always understood in those terms. Painting interventions that fundamentally aim at some form of public participation also generate difficult questions such as: How wide and effective has the participation been? What is the legitimacy of these new elements of identity when not everyone in the represented area recognizes or agrees with the paintings? What would participants say about their own participation? Who and what got visibility throughout the paintings?

With those questions in mind, and with an aim of fostering creative participation and personal development, I organized the action research ViverCor Corabitando/ LiveColour Colourinhabiting, which took place initially at São Cristóvão (Conte, 2012), and, subsequently, at Ruinha in the city centre of Montemor-o-Novo, in 2015.

AN ACTION THAT SEES AND GIVES TO SEE

The initial concept for the action that was approved by the population reads as follows: “ViverCor Corabitando/ LiveColour Colourinhabiting is a proposal for a community action. This project wishes to work together with residents of a street or place, to transform the public space by repainting its facades. Each painting will start from a drawn image, and each such drawing will result from individualized research of each participant, followed by a working-drawing-dialogue with the researcher. As a starting point for drawings, participants are invited to look for personal objects, local expressions, thoughts, emotions...”

Figure 1: "We brought to the public something that is private, very private. I have shared. I deeply believe in what I wrote [be strong and you will overcome], in that value. It is an appeal to others to put it in motion as well. It is an appeal. The object itself is not unusual [a buckle of a cowbell]; it is an emotional value" (Rosa Carvalho, São Cristóvão, 2012).

The concept necessitated that before starting the “negotiation interviews” (the working-drawing-dialogue with the researcher), all participants had already performed their own personal research, and by so doing, answered the implicit question "what do I want to say about me on my facade?" The project helped create singularities, with paintings consisting of both text and drawings (see Fig 1.-4.), in what otherwise might be consider modest regional architecture, but deeper than that, it resulted in the complex exercise of seeing and giving to see the people of the place, their things and their ideas.

Figure 2: "I learned to paint in 2009. I had an accident... I could not do anything and had to find an occupation. So I hung on to anything I could do... that's how the paintings and Alentejo flowers appeared [motive chosen for the frieze made under the roof tiles]. It was with the painting courses that I managed to survive those three years, that I overcame the difficulties of not being able to move. (...) We chose the verses of the song «My Alentejo» which is a poem that tells us a lot. The design was thought in a way to emphasize the bar. I love the colour yellow, it is more cheerful. (...) In comparison, grey is, by what I've heard ... is that families whose young men went Overseas (to the colonial war) painted the bottom in grey. And it was a dark grey, a lot darker” (Gertrudes Serrano, Ruinha, 2015)

Figure 3: "We used to do lace [the drawing of her first lace, in the picture, was the object chosen to make the frieze under the roof tiles], in the afternoon we had shade from the edge of the hill and we'd sit outside. Each one doing the work they had to do ... we worked on the farm from sunrise to sunsets, the «mordomo» even used to go to the hilltop to announce the end of working time, with the sun hiding behind him... and then we would work on the land they had given to my father, my father was «manajeiro» and therefore was entitled to a piece of land to cultivate white barley, barley oats, wheat fields, rye, and there we were working from sunset until the twilight [literal translation: to the last breath of the daylight, the chosen expression to paint on the facade] which is when we cannot see any longer. (…) Whoever takes the grey out of me, takes everything from me ... because it's the colour I like the most in the houses… I like grey it's a finer colour. This house was always grey.” (Luisa Quadrado, Ruinha, 2015).

Figure 4: “If you can see, look. If you can look, notice.” (António Fitas, São Cristóvão, 2012).

LiveColour Colourinhabiting’s work was accomplished with and by the communities where we worked, through reflection on the people’s values—family, affections, maxims or ways of life, landscape, architecture, colours, intangible heritage—and by translating those reflected-upon values into paintings.

As a result, the visibility brought by LiveColour Colourinhabiting is due not so much to any eye-catching quality of the paintings (which, to the contrary, were kept simple for visual integration and ease of reproduction), but, instead, to the paintings’ individual, intimate, but also communitarian characteristics, to their belonging to a people involved in transforming their space. These aspects come into view in all the paintings, and were confirmed in the post-intervention interviews of participants and non-participants, where result and process were mingled in aesthetic appreciation: "the beauty is in the proposal, in the acceptance and negotiation;" "The paintings beautify the houses, in addition... symbolize each person's house, I know, but I can't say... the painting is what a person feels and fortifies, and because it is aesthetically beautiful. It's the inside of the person, what he or she thought... it's beautiful to see and feel."

Despite this very personal tone, the carefully selected content of drawings and the common language that unifies them meant that each individual's heritage was recognized as part a collective heritage, and consequently, that the visual identity created was at once individual and collective: "The paintings belong to all, to those who made them and to others" (participant answer); "It made the village known, that is very important. Everyone saw in the social network and on television ... here we are very isolated... at the end of the world... Here, this of being seen and of having someone who understands people ... that is very valuable here" (non-participant answer).

Finally, it was understood that LiveColour Colourinhabiting offered a possibility to fulfill human needs (Max-Neef, 1986), most obviously those of participation and identity, but also affection, creation, understanding, leisure and freedom. Freedom here can be understood as an avenue of expression, but beyond that, as motivation and aspiration: “A door was opened, LiveColour changed the why not to do?" (non-participant answer).

CONCLUSION

The participatory painting proposals are several, as are the hues of participation. The practice proposed with LiveColour Colourinhabiting primarily dedicates to listening to people, and only then later to transforming public space. It was confirmed that this practice brings clear personal benefits, and not only the creation of spatial differentiation. People are at the center of all action, and without their contributions nothing is accomplished. Consequently, the people recognize themselves in the change that they, themselves, create, and feel an increased engagement with and motivation to take care for their surroundings. The work demanded time, a resource difficult to find in this contemporary way of life that does not allow us to stop, hesitate, doubt, change ideas or return to the beginning; the time-intensive nature of this work, therefore, served as something of a didactic of attention (Han, 2012). Attention was turned to our own and others' ways of expression, to architectural details, to new and old colours. Such a turn of attention is intended to work not only with deprived neighborhoods, where art and social work have mixed roles, but with everyone shaping a path for a culture that recognizes and celebrates the details, where every string has place on the cultural fabric.

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The Colours of Transcendence: Mystical, Metaphysical and Spiritual Significances of Colour in Islamic Art and Architecture

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ABSTRACT
The present research paper aims to shed light on the various spiritual and metaphysical potentials and dimensions of colour through the analysis of Islamic Architecture and Art using the Sheikh Zayed Grand Mosque in Abu Dhabi as the main example. How colours transcend their very physical nature, allowing for a communication and embodiment of that which is divine, is one of the main aspects that the article aims to clarify. In the theoretical section, the paper firstly defines Islamic spirituality, in terms of its founding roots and the fundamental idea of beauty as a metaphysical and archetypal essence, and also clarifies the innate significances of light, geometry and colour. In the experimental section, different principles and ideas are announced that exemplify the transcendental and archetypal essence of colour in the mosque. Lastly, the results and conclusions show that colour is a fundamental agent of transcendence, re-connecting the human being to the spiritual dimensions.

Keywords: *Islamic architecture, Islamic art, Colour, Transcendence, Spirituality*

INTRODUCTION

Islamic art and architecture is deeply connected to its spirituality. Light, colour and geometry, as will be demonstrated are primal essences through which man re-connects to the spiritual dimensions. Part one contains the 'Definition of Concepts, Metaphysics of Beauty and Spiritual Principles', followed by 'Colours do not act alone: Light and Geometry' where the transcendental abilities of colour in Islamic Art and Architecture and its indivisible unity to light and geometry are clarified and 'The Metaphysical and Spiritual Essence of Colour' that elucidates the metaphysical and philosophical tradition. In Part two**,** the Shaekh Zayed Grand Mosque is analyzed: 'Whiteness:

Creating Purity and Transcendental Unity', 'The Reverence for Nature and the Allusion of Paradise', 'Divine Truth and The Unity in the Multiplicity' and 'Spiritual Harmony and Other Transcendences' all clarify fundamental aspects of colour and its according metaphysical and spiritual dimensions.

PART ONE

Definition of Concepts, Metaphysics of Beauty and Spiritual Principles

Since the pre-existing philosophical knowledge and artisanal traditions from Christian, Persian and Indian cultures were re-applied by converted artisans and philosophers into the new Islamic religions in order to reflect and embody the principles of the Qur'an, its creations reflect a great complexity of metaphysical and spiritual ideas. Aiming to promote plurality, unity, integrity, openness and integration, and believing that the transcendence and infinite nature of God couldn't be represented in human form, an aniconic (non iconic) language was developed.

Believing that all physical forms (*dhakir*) were outward manifestations of an inner essence (*batin*) that reflected the ultimate source of all existence, Islamic language aimed to embody and represent this intangible and infinite world. Human creations reveal the *batin* through a metaphysical idea of beauty, which as Burckhardt (2009 p. iii) explains, is a divine quality which "most directly recalls pure Being.'' Creations that possess beauty, thus, are ''vehicles for the attainment of Truth (*al-Haqq*)'' (Nasr, 1987, p. 202), and reveal the underlying spiritual knowledge (*hikmah*) that sustains both the physical and the spiritual world, acting as special signs (*ayah*) that possess spiritual and metaphysical 'messages' (*dhikra*). It is an archetypal essence, that echoes the Platonic archetypal idea of 'pure forms', deeply rooted in the idea of intellect. It is the intellect that can understand the "intuitive knowledge of the Absolute" (Azzam, 2002), comprehending metaphysical wisdom through archetypes and perceiving divine unity. Azzam (2002) further explains that "What we see or understand as beauty is only universal because it reflects the principle of beauty in the realm of the archetypes." (Azzam, 2002). The archetype is thus part of the divine world, and it is the intellect that understands it and possesses the ability to recreate it, granting the work its sacred dimension and linking it directly to God. One last principle that is of vital importance is the idea of *Tawid* which is the idea of divine unity, reflected as one God and in one humanity. As a synthesis, Islamic Art and Architecture creates a 'sensible image' of the 'spiritual world', representing ''the form of a spiritual meaning'' (MahdiNejad *et al*., 2016, 1086) and act "as a bridge or vehicle to transmit the realm of heaven into our physical world." (Azzam, 2002). In order to achieve this it relies on the intellect (the capacity to perceive and re-create Divine truth) and on the use of archetypes (representations of higher models, physical sign or symbol of the real essence).

Colours do not act alone: Light and Geometry

The transcendental abilities of colour in Islamic Art and Architecture are inseparable from the immaterial essence of Light and the mathematical structural components of Geometry. It is a combination of these three elements, that brings the spiritual and metaphysical dimensions to life.

The Qur'an claims that "God is the light of the heavens and the earth" (24:35). This makes light be perceived as a profoundly spiritual and metaphysical essence that acts as a symbol of God. Faleh adds that "Light is both a physical connector as well as a spiritual element that transcends its physicality to express a connection with the divine world. " (Faleh, 2016, p.174). Light, a transcendental element, is thus manipulated and considered in ways that create different experiences, generating different allusions and specific metaphysical and spiritual significances. Since symbolically, light acts as the symbol of revelation and understanding, the presence of light in every mosque through stained glass windows, large chandeliers, plays of shadows or vertical windows, allows the idea of 'revelation' to be made clear in different ways. Architecture itself is also considered as that which makes 'light' be revealed in the world, and so, every element of the architectural space, from the columns, the muqarnas to the ceramic tiles, are all considered as conductors of Light, reflecting it or allowing it to permeate into the ground, in subtle yet beautiful ways, revealing the presence of God. Geometry also has a great spiritual significance: it is understood as the inner 'dynamics' of nature, as the supreme example by which God creates, being generally perceived as the language of the divine in a physical form. Geometric creations connect to the divine, not only through their individual symbolic significances (such as the circle representing unity) but also through their visual appeal that allows one to be projected into a contemplative condition, which in Islamic spirituality, connects the observer with a higher state of consciousness. The very conception of the complex patterns and tessellations metaphorically echo the way God creates, omitting the process itself and showing the end result. Their interweaving and interconnecting essence, also reflect the principle of *tawid* (divine unity), and allude to that which is infinite, thus echoing the main characteristic of God. Author Nasr adds another interesting significance, claiming that they reflect the "interior structure of corporeal existence" (Nasr, 1987, p. 49), mimicking the compositions of atoms centuries before the telescope.

Figure 1: The Exteriors of the Sheikh Zayed Grand Mosque. Pictures taken by Sarah Frances Dias.

The Metaphysical and Spiritual Essence of Colour

Colour, just like light and geometry, has a profound metaphysical and spiritual essence that greatly surpasses the symbolical and metaphorical essences it may possess. These particular significances are greatly derived from the Qur'an that claims that "men too, and beasts and cattle -- diverse are their hues." (35: 28), referring to the wide chromatic variety of God's creations. Colour, thus, is seen as an essential attribute of that which is holy, and thus, as a 'signifier' that leads man back towards that which is divine. Thus, specific colour combinations, specific uses of colour, become maps for the archetypal world of the divine. But further, because colours are a manifestation of light, and light is a symbol of God, they reveal ''the interior richness of light'' (Burckhardt, 2009, p. 84) and act as veils ''through which the colourless light can be perceived'' (Soucek, 2011). In this way, colours also possess the spiritual significance of allowing God to be 'seen'. Naturally associated to the abundance of nature, colours are also symbols of paradise (the ultimate abundance of God). They embody the essence of the divine through their very nature and are fundamental keys for unworldly transcendence.

PART TWO

Whiteness: Creating Purity and Transcendental Unity

The main principle that Islamic Art and Architecture aims to embody is the idea of unity, *tawid*. In the Sheikh Zayed Grand Mosque, this metaphysical and spiritual principle is present in various ways. First, since the exterior materials of the mosque are predominantly white, it embodies the significances of light itself, acting as a symbol of purity, unity and God. Matter is dematerialized into weightlessness and principles of purity and spiritual peace are brought forth. Since for Nasr (1987), white also echoes the qualities of 'cosmic existence' (Nasr, 1987), the mosque becomes an icon for the unworldly, emerging as a white vision against the blues and yellows of the surrounding atmosphere. Because of its colour, it not only embodies but also acts as transcendence, serving as a metaphorical and spiritual 'beacon of light'. Physically as we wander barefoot through the space, we too, become weightless. The combination of gold and white in the semi-enclosed arcades that surround the main courtyard, embodies the qualities of transcendence, combining the idea of spiritual purity and light (white) with the richness of the divine (gold). Gold acts as the ultimate symbol of the Divine, of the soul and is associated to intangible divine perfection. As we notice the gold accents, suspended mid air, we seem to be reminded that even in the emptiness there is something transcendent which emerges. As we wander in this timeless space, we too become one with ourselves and with the divine.

The Reverence for Nature and the Allusion of Paradise

Nature doesn't only define the codes of geometric composition, it also shows man the rhythms of life and serves as the main inspiration for colour uses. It is from the rhythms of nature that the idea of the Arabesque was developed as an organic ornamental composition. We see these flowing rhythms of thriving nature adorning the walls of one of the main rooms of the Mosque, and carved in marble (as accents of colourful red and orange dancing flowers) on the floors and on the walls of the outside arcades, which combined with the blue of the water ponds beside it, give a profound feeling of peace, bliss and happiness. These rhythms of nature are also found in the gold columns accents, whose design alludes to the top of a palm tree. This flowing movement of organic life, echoes the energy that sustains all creations, acting as a remembrance of the origin of life and echoing the abundance of paradise, and of eternal life. It is in paradise that life blossoms beyond the limitations of physical form, and thus, the large overflowing colourful flowers also remind us of the abundance of the spiritual dimensions.

Figure 2: The interiors of the Sheikh Zayed Grand Mosque. Pictures taken by Sarah Frances Dias.

Divine Truth and The Unity in the Multiplicity

The polychromatic exuberance of the Murano chandeliers, aim to materialize transcendence, associating vibrant colours to the metaphysical and spiritual dimensions of light. The polychromy possesses ''a nature of unification and oneness.'' (MahdiNejad *et al*., 2016, 1079), acting as a metaphorical reminder that there is a profound unity in multiplicity. It signifies ''the differences of various expressions and appearances'' (Faghfoori *et al*, 2014, p.10) and the unity between these differences. The full spectrum of colours communicates oneness, and thus acts as a beautiful materialization of the *Tawid*, reflecting the unity of the Divine and of God.

Spiritual Harmony and Other Transcendences

As one walks through the main prayer room of the space, one can't help but be mesmerized by what seems to be an infinite array of colours and light reflections. Faleh (2016) claims that the reflections of light "add a living element" (Faleh, 2016, p.180) in mosques, create an otherworldly condition, and in fact, in this mosque too, as the light reflects on the different ambient colours it creates yet another form of transcendence. Another significant note is that the variety of vibrant hues and the complexity of the combined colours create a rich and beautiful sense of harmony that acts metaphysically as a link to spiritual harmony. Together, through variety, balance, and a profound sense of equilibrium, each space and each predominant 'colour', acts as a symbol of divine harmony with God.

DISCUSSION

The studies make it clear that the use of colour far surpasses its individual symbolical and metaphorical uses, permeating into deeper cosmological, metaphysical and spiritual dimensions. Geometry, colour and light, with their combined spiritual significances, create a heightened contemplative experience, that allows man to move beyond the material and physical components that surround him, into the more intangible realm of the spirit. Colour, with its archetypal nature, as that which exists abundantly in the eternal, inspires wonder and promotes contemplation, promoting unity and integration in man and allowing man to be closer to the infinite. Transcendence itself, is precisely (and simply) this blurring of perception between the material and the spiritual. Thus, through colour, light and geometry, matter becomes transcendence, echoing and reverberating infinity itself.

CONCLUSION

Comprehending this metaphysical and spiritual dimension of Islamic creations, leads to the '' (…) understanding of the spiritual realities that lie at the root of a whole cosmic and human world.'' (Burckhardt, 2009, p. iii), and allows us to understand that a universal transcendence is possible through specific uses of colour. Materializing the timeless in the temporal, giving form to the unseen, creates universal understandings between times and cultures, and allows us to see and use colour in new and other significant ways.

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Silent colours: Designing for wellbeing using smart colours

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ABSTRACT

When used within textile printing, smart colours have expanded the design possibilities for textile patterns as relates to both motifs and, more importantly, uses. Smart colours–suggest new functionalities and provide specific perceptions, reactions, and activities in terms of usage. At the same time, the need for peripheral information sources that are less intrusive than many of the everyday devices of the present has continuously been addressed to improve wellbeing, e.g. by making life more manageable and meaningful through the use of technology in everyday life. We aim to increase knowledge of the design qualities of smart colours, which is of use in relation to creating non- or less intrusive ways of displaying peripheral information. This paper focuses on the character of colour transition and discusses different colour-changing possibilities with regard to surface patterns; that is, from the perspectives of different levels of change and complexity and in relation to levels of intrusiveness and information comprehensibility.

Keywords: *Smart colours, textile structures, textile design, non-intrusive, interactive displays, wellbeing.*

INTRODUCTION AND BACKGROUND

Ever since the notion of calm technology was introduced in the 1990s (Weiser & Brown, 1995), how we live and can live with interactive devices and systems has been explored and discussed (e.g. Janlert & Stolterman, 2017; Shelton & Nesbitt, 2016). If our interactions with devices can move back and forth between the periphery and centre of focus in a non-intrusive way, life may become more manageable and less stressful, increasing wellbeing. For instance, in our daily lives we are bombarded with external noise, generated by all manner of technologies. 'Noise Pollution: Non-Auditory Effects on Health' (2003) is a research project in which Stansfeld discusses the various effects of noise on physical and mental health, as well as behaviour and social interactions. Stansfeld highlights the fact that environmental noise has physiological effects such as high blood pressure, increased heart rate, and hormonal disturbances, as well as longer-term responses including anxiety and psychological disturbance. The question is whether we can help people to be more in control of their situation in order to increase wellbeing through colour and pattern design.

Patterned textiles and wallpaper have always been part of our environments, functioning as aesthetic assets that improve wellbeing by acting as graphically complex information displays, for example. However, the development of smart colours has re-positioned textiles as aesthetic and communicative media – new methods of creating expressive ambient displays through colour and pattern change. Through experimental research, the area of smart colours – in this case, leuco dye-based thermochromic inks in particular – has been explored as a possible replacement for more intrusive ways of receiving and expressing information as peripheral interactive displays (Bakker *et al*, 2015), for example.

Research into the area of using colour to express visual information as a way of influencing human wellbeing has thus far shown that colours can be used to create certain ambient effects, which can lead to visual stimulation or relaxation (Lengen, 2017). Similarly, the project described in this article examined the role of textiles that can change colours. A change in colour is the subtlest in the hierarchy of phenomena that attract our attention, wherein sound and movement are the most intrusive and difficult to ignore. Together with the fact that a colour change opens up for a large, expressive, and non-binary palette, this means that changes in colour are suitable for communicating in a more ambiguous and subtle way.

Thermochromic inks, which generally change colour in response to temperature fluctuations, change from one colour to a lighter hue when heated. Mixing thermochromic inks and static pigments enables the resulting pigment to change from one colour to another (Kooroshnia, 2017). Moreover, applying thermochromic inks to textiles, e.g. knits or woven structures, can further enhance the textural character of surfaces. The palette that can be obtained using thermochromic inks has therefore been explored by several researchers in the field of textile interaction design (Orth, 2004, Hallnäs *et al*., 2006, Kooroshnia, 2017), however, little research has been performed on the potential of changes in colour in relation to designing for wellbeing.

THERMOCHROMIC INKS

The silent aspect of colour transformation was explored through a practice-based research methodology. The structure of the experimental work aimed to explore the transitional aspect of colours on textiles as a method of analysing and describing the changes that can be achieved using the thermochromic inks combination with static pigments. Four series of prints were produced using thermochromic inks with an activation temperature of 31°C.

The first of these consisted of three fabric samples produced using thermochromic inks in primary colours; the second consisted of six fabric samples made using one thermochromic ink and one static textile pigment paste; the third consisted of six fabric samples produced using multiple thermochromic inks and one static textile pigment paste; the fourth consisted of two fabric samples, one of which was produced using three thermochromic inks with different activation temperatures and the other using three thermochromic inks with different activation temperatures and a static textile pigment paste. This transition can be subdivided into three categories:

1: Fading: A graduated scale, ranging from Colour A to a lighter version of Colour A, and back again to Colour A (Fig 1).

2: Bridging: A graduated scale, ranging from Colour A to Colour B, and back again to Colour A. Several bridging colour mixtures can be used with the same Colour A, resulting in some areas changing from Colour A to Colour B during activation and others changing from Colour A to Colour C, and so on (Fig 2 and 3).

3: Continuous bridging: Thermochromic inks with different activation temperatures can also be used to achieve a more continuous bridging effect. Thus, Colour A can change to Colour B and then to Colours C then D, and back again (Fig 4).

RESULTS AND DISCUSSION

In the paragraphs that follow, the design qualities of thermochromic inks are discussed based on three aspects and related notions focused on in the literature.

Level of colour change

The level of colour change refers to the contrast between the initial and end expressions of the textile. This contrast can be expressed as a dramatic change in hue or colour from the initial state. Accordingly, the level of colour change refers to the extent to which the colour is experienced to differ between the activated and non-activated states. This aspect can be related to the desired level of intrusiveness as a design dimension, as discussed by Ames and Day (2002).

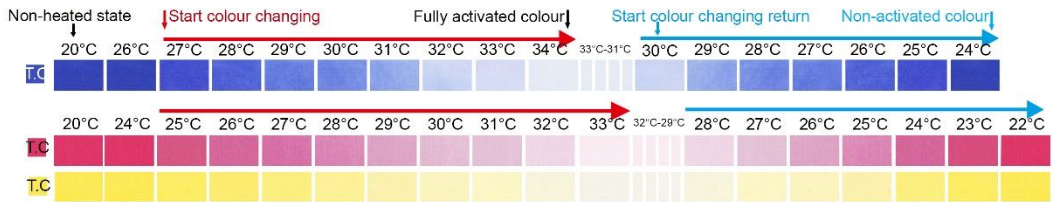

Figure 1: A transition from one colour to a lighter version creates a smooth, soft colour transition, beginning with a visible colour and moving to a near-invisible one. In this series, colour changing of blue to the lighter version of same hue is the most intrusive one in comparison to yellow one. For the darker colour, the transition is more intrusive. It is noted that the level of intrusiveness in all the figures was rated from high (top) to low (bottom).

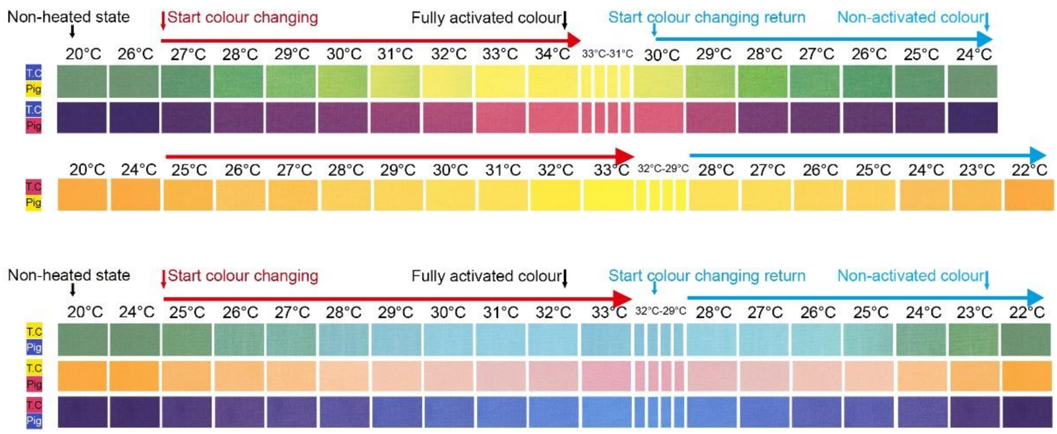

Figure 2: For the first three bridges, a thermochromic ink and a static textile pigment paste adjacent to each other on the colour wheel (referred to Iten colour wheel) were used to create a smooth but strongly contrasting colour transition. For the second three bridges, a thermochromic ink and a static textile pigment paste adjacent to each other on the colour wheel were used to create a smooth, subtle, and sophisticated colour transition and a serene and comfortable colour palette.

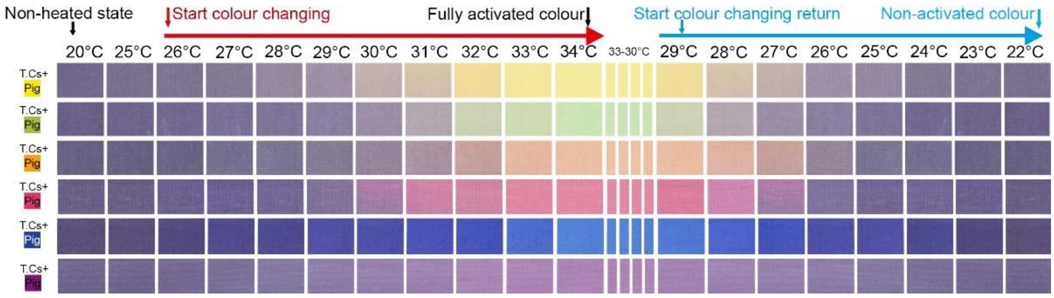

Figure 3: For the first three bridges, thermochromic inks and static textile pigment pastes in complementary colours were used to create vibrant and strongly contrasting colour transitions. The bridging colour transitions in which the static pigments were green and orange had the same strong visual contrast as when the static textile pigment paste used was yellow, but there was less tension. Similar to the previous example, thermochromic inks and static textile pigment pastes adjacent to each other on the colour wheel were used for the second three bridges, creating smooth, subtle, and sophisticated colour transitions.

Figure 4: The colour transitions involved continuous bridging to create vibrant and contrasting colour transitions.

Figure 5: The sample on top consisted of four layers of ink and pigment paste mixtures which are printed on top of one another; that results in a complex dynamic surface pattern with the potential to convey more information in comparison with the simple three colour surface pattern.

Level of colour complexity in the surface pattern

The level of colour complexity refers to how the inks and pigment pastes are mixed (fading, bridging, and/or continuous bridging) and printed next to one another as a surface pattern (for a bellowmore in depth discussion of mixing colours see Kooroshnia, 2017). A higher complexity results in a pattern with multiple changeable elements embedding more information capacity, as is discussed by Pousman and Stasko (2006), and a greater level of comprehensibility, e.g., by providing access to the user for additional peripheral information without interruption, as is discussed by McCrickard and Chewar (2003).

The rhythm of colour

The aspects of time and colour rhythm affect the classifications discussed above. The time required for sufficient heating to take place and distribution of heat in the pattern depend on the type of heat source used. The time required for cooling depends on the ambient temperature and/or the type of cooling source used. Together, these parameters affect how quickly the colour change and thus the level of intrusiveness. Variation in time spans between the colour hues and tones can create disruptions in the central activities, but might also introduce moments of reflection and rest, e. g, allowing users to successfully complete central tasks.

Figure 6: The sample was produced using inks with activation temperatures 27, 37 and 47°C and green static pigment. Fast or slow heating effects the visual expression. Slow heating allows observing the complete range of colour transitions over a longer period of time and in greater detail, e.g. colour changing becomes less intrusive. Here, fast heating becomes more intrusive.

CONCLUSION

The research presented in this article proposes a new method for designing non-intrusive textile displays to be used as aesthetic peripheral communication systems. This research thus positions itself at the intersection of various design disciplines, and so uses the methodologies of interaction design to discuss the design of non-intrusive peripheral communication and proposes textiles as a medium for expressing graphical information in the form of colour transitions. Thermochromic colours were combined with textile materiality to propose suggestions relating to the forms that environmental wellbeing could take. As regards the body or spatial design, colour-changing textiles offer an alternative perspective on how information technology can be used to display complex patterns and colour transitions. The aim is to contribute to the development of multidisciplinary design methods wherein colour transitions are factors that can be used to increase wellbeing and are defined by complex textile expressions.

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Impact of Colour Combinations on LCD Display Legibility

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ABSTRACT
A constant rise in technology and the expansion of the Internet are two main factors which have contributed to the decline of the use of printed media and a continuously larger circle of display readers. Despite high display resolutions, problems in the legibility of typefaces still occur. Many typefaces may well be readable in print, but cause more difficulties when being read on displays. The aim of this study was to examine the influence of colour combination on the legibility on LCDs to establish which type style is appropriate for a coloured text to be legible. Two different, specially designed typefaces for display use were tested in three different colour combinations involving four colours, i.e. dark grey, dark blue and red on white. The reading speed and fixations were analysed with an eye-tracking device. The result of the study showed that the colour combination and typeface design contribute to better legibility.

Keywords: *colour combination, eye-tracking technology, LCD display, legibility, typography*

INTRODUCTION

A constant rise in technology and the expansion of the Internet are two main factors which have contributed to the decline of the use of printed media and caused a continuously growing circle of display readers. This has brought the evolution of high resolution displays, especially liquid crystal displays (LCD), which are among the most commonly used ones. Despite high resolutions, problems in the legibility of typefaces still occur. Many typefaces may well be readable in print, but cause more difficulties when being read on displays. For better display legibility, the typefaces Georgia (*Georgia*, 2017), i.e. transitional type style (McLean, 1986; Možina, 2003), and Verdana (*Verdana*, 2017), i.e. sans-serif type style (McLean, 1986; Možina, 2003), have been designed.

The communication through a page or a display requires from the reader to translate symbols into meaning. Legibility refers to how easily this process is performed. To make reading possible, the text must be visible and recognisable; however, visibility and recognition are influenced by the typographical choice. Furthermore, legibility is also influenced by the verbal capabilities of the readers (Reynolds, 1988; Možina, 2001a).

Legibility and the reading process can be studied by tracking eye movement. Reading does not occur as a continuous movement of the eyes along the lines of a text, but rather as a sequence of rapid eye movements (saccades) and individual fixations, which typically last between 200 and 250 ms (Abadi, 2006; Rayner *et al*, 2001). Fixations are short stops at individual words or groups of words that (within their duration) enable the brain to process information, while saccades are extremely rapid eye movements, the function of which is to align the image of the object with the area of the fovea.

A large number of studies on legibility points to its importance. There is a big discrepancy in understanding what makes a text legible. Nevertheless, it is possible to determine some general guidelines that can help make a text legible. There are some typographic characteristics to be observed to make a text more legible. For a small type size, it is known that the differences in stroke weight and typographic tonal density (TTD) are significant (Možina *et al*, 2010; Rat *et al*, 2011), since they influence text legibility. Furthermore, a number of other typographic characteristics needs to be observed in order to make a text more legible, i.e. distinctive character features (counter shape), x-height, ascender, descender, serifs, contrast (stroke weight), set width, type size, leading (i.e. space between lines) etc. (Bix, 2002; Gaultney, 2001; Franken, Podlesek, Možina, 2015; Možina, 2001a; Reynolds, 1988; Tracy, 2003). Sans-serif typefaces consist of only main thick strokes and are of simpler shape.

For better visibility of information, colour can be of use as well (White, 1996). Most typefaces are designed to be read as black letters on a white background and they in this manner achieve optimum legibility. There is nothing ambiguous about black and white. They are completely balanced opposites, offering exquisite contrast. When reading large amounts of type, the contrast of black and white is what readers are most accustomed to (Carter, 1997; Možina, 2001b). To use colour for better typographic visibility, the contrast is poorer and we therefore have to take into consideration some results of previous research (Carter, 1997; Itten, 1961; Možina, 2001b; White, 1996): As type decreases in size, colour contrast has to increase in strength (Carter, 1997; Možina, 2001b). Letter and word spacing, and leading affect type colour (TTD). Similarly, when letter and word spacing and leading increase, TTD decreases (Carter, 1997; Keyes, 1993; Možina, 2001a). Therefore, when colour is used to improve visibility, larger type size or black typefaces or sans-serif typefaces need to be used. Furthermore, larger leading should be applied, when colour is used for typography or background or both (Carter, 1997; Možina, 2001a; Možina, 2001b).

To attract the reader’s attention, blue and red colours are often used with white background (Pušnik, 2016). The red colour is associated with danger, energy or warmth (Thussu, 2007). It can activate an avoidance motivation, and enhance performance and detail-oriented cognitive tasks (Mehta and Zhu, 2009), and in turn, it can lead to greater attention. The blue colour is supposed to represent trust, hope and serenity (Thussu, 2007). Despite the subdued tone, the combination of blue and white can affect the recipient and is a visible source of additional information (Deidre, 2003; Thussu, 2007).

The legibility study (Franken, 2015) of different typefaces in different light-dark contrasts with different backgrounds displayed on an LCD display showed that a better contrast (however not maximum, i.e. black on white) increases reading speed. Therefore, the aim of this study was to examine the influence of colour combination on the legibility on LCD displays to establish which type style is suitable for a coloured text to be legible.

EXPERIMENTAL

Two different, specially designed typefaces for display use (one transitional, i.e. Georgia, and one sans-serif, i.e. Verdana) were tested in three different colour combinations involving four colours, i.e. dark grey (#1A1A1A) on white (#FFFFFF) (Combination 1), dark blue (#142451) on white (Combination 2) and red (#C62026) on white (Combination 3).

In controlled laboratory conditions (*ISO 3664*, 2009), the reading speed and fixations were analysed with an eye-tracking device Tobii 120X. The texts in both typefaces at 12 pt (16 px), in 130% leading and all colour combinations were displayed on a 24-inch LCD display with the resolution of 1900 × 1200 pixels at a 120 Hz refresh rate. In each typeface and each colour combination, a different text was presented to the tested individuals. We used six different texts from *National Geographic* (Slovenian edition) with the length of between 97 and 115 words, comprising between 10 and 13 lines (Figures 1 and 2).

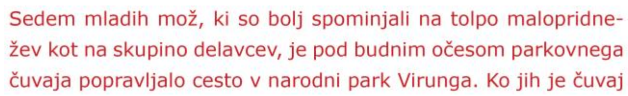

Figure 1: Part of text paragraph with Verdana typeface.

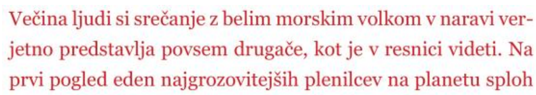

Figure 2: Part of text paragraph with Georgia typeface.

The time required to read 600 characters (in seconds) and the number of fixations were calculated. Forty tested individuals were between 19 and 22 years old with normal or corrected-to-normal vision. In line with recommendations (*ISO 9241*, 2012), they were positioned 60 (+/– 1) cm from the display. The texts were set in a CSS style sheet and displayed as a HTML document. In this way, we ensured a precise display of texts in the chosen size. The texts were shown in the centre of the display. The display sequence varied using the Latin square design, which was used for counterbalancing the order of texts.

RESULTS AND DISCUSSION

Figure 3 shows the influence of the used typefaces and colour combinations on the speed of reading. Figure 4 shows the influence of the used typefaces and colour combinations on the number of fixations.

On average, the reading speed was faster at the combination of the red text on white background (cf. Figure 3). At all examples, the texts prepared with Georgia were read the fastest, regardless of the used colour combinations. On average, the texts prepared with the Verdana typeface were read the slowest, the only exception was dark grey text on white background (Combination 1). Verdana is a sans-serif typeface and should thus have better legibility than a transitional typeface. Obviously, at this type size (16 px), big counter size, wide letters and thick stroke width led to lower reading speed. An interaction between a greater number of fixations (cf.

Figure 4) and slower reading was noticed, especially at the Verdana typeface. A larger counter size gave more fixations and consequently resulted in slower reading.

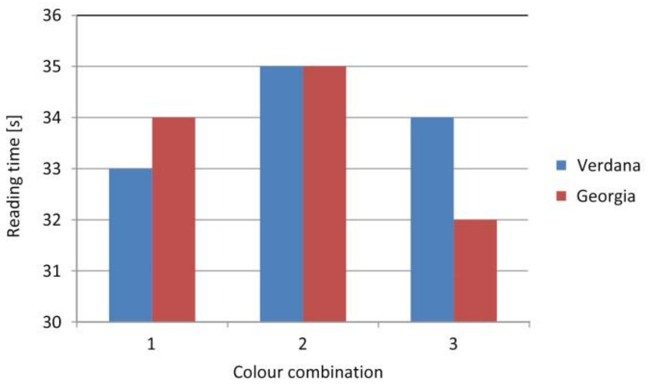

Figure 3: Reading time [s] of used typefaces in different colour combinations.

It was also interesting that the red text on white background (Combination 3) gave the fastest reading speed (cf. Figure 3) and the smallest number of fixations (cf. Figure 4), since this colour combination has the smallest light-dark contrast among the used colour combinations. Most likely, an unusual colour combination for a longer text (not only titles or a short text) held more attention by the readers. It was surprising that the blue and white colour combination with a strong enough light-dark contrast gave the worst legibility. Nevertheless, the reason is in the distribution of cones sensitive to short-wavelength light out of the fovea centralis, as there are more at the peripheral retina (Krauskopf, 1998). There should be no problem with larger objects in blue, while typefaces with bigger counter sizes in smaller type sizes in blue obviously make worse legibility.

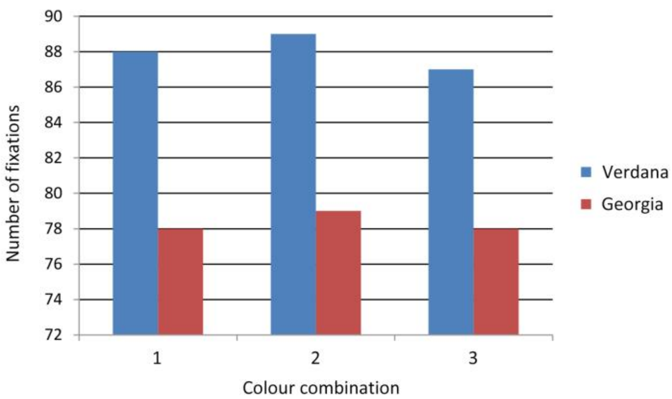

Figure 4: Number of fixations at used typefaces in different colour combinations.

CONCLUSION

The results of the study showed that the selection of a particular colour combination and contrast greatly affects the speed of reading and legibility. Less contrasting or visible colour combinations of the text and background were read more slowly, i.e. blue and white, than the more contrasting or visible ones at both typefaces. At both typefaces, it is seen that at slower reading speed, more fixations are needed and vice-versa. It might also be concluded that the transitional typeface Georgia is more legible than the sans-serif typeface Verdana. Nevertheless, it appears that different colour combinations had different reading speeds at different typefaces (transitional vs sans-serif). Consequently, in order to be able to give an appropriate suggestion for usable display legibility, the study should be thought through with more diverse colour combinations and contrasts. The result of the previous study (Franken, 2015) namely showed that the reading speed increases when the background is not completely white.

The result of the study showed that the colour combination contributes to the speed of reading and to better legibility. An appropriate contrast and colour combination can facilitate the legibility of displays.

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The Development of Methodologies for Designers Engaging with Digital Colour Inkjet Printing in Textile Design

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ABSTRACT
Digital textile printing (DTP) offers exciting, creative potential and entrepreneurial business models in textile design. However, there is a marked difference between screen-colour to print-colour. Colour results are affected by numerous variables which a textile designer will be required to understand, and experiment with, in order to feel colour confident. A number of variables were tested using a Practice as Research methodology, to determine the impact on printed colour outcome. This paper presents investigations which focused on the development, and generation of, visual indicator methods and ICC profiles generated from data, accumulated through measuring printed colour differences on substrates. The aim to provide an indication of colour changes when printing on different fabric substrates, allowing designers to make adjustments to designs to obtain a better colour match, and develop their colour expectation knowledge.

Keywords: *Colorimetry, Colour in the Arts and Design, Digital Colour, Digital Textile Printing*

INTRODUCTION

The development of digital printing is a major change within the textile design process as a designer is no longer restricted to number of colours or repeat patterns, and may include photographic images and intricate detail in their design work. Digital textile printing (DTP) provides unprecedented opportunity for designers to offer bespoke, and customisation of, designs without large set up costs, leading to new entrepreneurial business models in the textile industry.

Digital textile inkjet printing is a non surface-impact print process where colourants (primarily dyes, but increasingly pigment inks) are jetted in a dithered, matrix of dots, onto specially treated fabric, to create the appearance of solid colour. The colourant sits on the surface, although, secondary processes, allow dye molecules to further permeate the fibres. Additionally, DTP may include dye sublimation, solvent, latex, ultra-violet and direct-to-garment printing, for example T-shirt printers.

Reduced ink wastage and water use makes DTP a more environmentally sustainable printing method in comparison to screen and rotary printing. Short print runs and the ability to react quickly to market trends allow businesses to carry less stock, reducing storage costs, and the likelihood of stock wastage as fabric is printed to demand.

However, there is a marked difference between screen-colour and print-colour. A textile designer will be required to experiment with a number of variables in order to feel confident about the colour outcome of their print. For example: the ink range and colour bank of the printer, variations between one machine and another, the structure and composition of the substrate, fabric pre-treatment, secondary processes and the printer's achievable gamut will all affect final results. Colour is critical in the textile industry both in terms of meeting trends, client requirements and obtaining consistent colour.

THE RESEARCH PROJECT

The wider research inquiry considers how designers can ensure colour assurance when digitally printing through an exploration of existing colour tools and methods. The aim, to produce an accessible colour toolkit for practitioners and SMEs, that may not have access to highly technical equipment and software.

The research set out to identify the variables which affect colour outcome. These were then explored, using a Practice as Research methodology, to discover the impact on printed colour. Existing software, methods and processes were surveyed to determine their usefulness and accessibility. The work was documented, and reflected upon, providing a durable record of the practice and progress of the research inquiry. The thinking-doing approach was informed by Professor Robin Nelson's understanding of Practice as Research and follows the 'know-how', 'know-that', 'know-what' model of praxis he has established. This model is useful for the research because textile design, and working with cloth, is naturally a nonverbal experience.

This paper presents investigations which focused on the generation of ICC profiles using data accumulated from measuring printed colour differences on substrates.

EXPERIMENTAL: THE GENERATION OF INDICATOR ICC PROFILES

The research observed changes to the overall appearance of an image displayed on screen and subsequently printed, by assigning different output profiles to a specifically created colour test collage in Adobe Photoshop Creative Cloud (APCC). The research considered whether an output profile could be created which indicated to the viewer the colour alterations to expect when printing onto different textile substrates. The profiles were developed using existing data, produced by the research project, which analysed colour shifts from the intended screen colour to the printed colour, across four substrates. The aim to provide an indication of expected colour changes to a designer viewing their image on a computer display, allowing them to make adjustments to obtain a better colour match and developing colour expectation knowledge.

Profiling is a means of comparing measured reflectance data, from RGB or CMYK colour ranges, produced by a particular device or devices, with known reflectance data from CIE models. Additionally, a profile describes each device's parameters (dynamic range, gamut and the tone reproduction characteristics). Data is stored in a look up table, used for mapping an input to an output value. Output profiles, used to display and output colour, are large two-way profiles which require multiple look up tables, to provide information about numerous colour possibilities. Profile maker software uses a colour target as a means of gathering information about the device's colour reproduction. This is measured and the returned data used to provide an overview of colour options for the look up table, limiting the amount of data to be stored. ICC profiles were developed by the International Colour Commission in 1993 as an open profile format which could be used universally across different software and devices.

To evidence that there is a difference between screen colour and print colour, and further variations between substrates, a colour chart was created, using the 1137 colours in the Pantone© solid uncoated colour library in APCC (Figure 1). The chart was printed onto four different substrates (wool, linen, cotton and silk) using a digital textile inkjet Mimaki TX2-1600 printer, with reactive dyes. The fabric swatches were compiled in a colour reference book alongside the corresponding numerical values (RGB, CMYK, HSB, Hex and LAB) and a paper print, as the closest visual match to the screen colour. This provided a broad range of colours and data for comparison, and demonstrated differences across the printed colour to the screen colour, particularly in neutral ranges such as greys, blacks and browns, as well as colours from the blue and magenta tonal ranges.

Figure 1: Gooby, B, 2017 Colour Reference Book (Researcher's own collection) Examples of the colour reference book. Each row consists of the digital numeric values (RGB, HSB, Lab, CMYK and Hex) The swatches (left to right) are paper print, wool, linen, cotton and silk.

A colour set, consisting of the first 24 colours in the Pantone© Library was used to reduce the data range from over five thousand swatches. This set covered a range of highly saturated, spectral colours (red to purple). The fabric swatches from this set were measured using a Kodak-Minolta FD-7 spectrodensitometer which returns sophisticated colour measurements using filters to measure the wavelengths reflected from the colour sample. The spectrodensitometer was set up to measure the reflectance value under D65 illuminant conditions, the standard for measuring textiles, and return LAB and wavelength (nm) values from 380-730nms. The LAB coordinates were entered into the colour picker tool in APCC to display a digitised version of the printed swatch, and corresponding HSB (hue, saturation and brightness) values recorded.

The digitised swatches were plotted onto colour maps to visualise hue, saturation and brightness (HSB) shifts from the screen colour, symbolising a digital lab dip test (Figure 2), to visualise for a designer how a colour might be expected to print, depending on substrate. The HSB colour model was chosen as a more accessible, and visual means, of representing colour changes, in comparison to the mathematical LAB model. A median value for each substrate's HSB shifts was calculated and recorded. A series of colour maps was produced and presented at the DataAche

Conference, Plymouth University, 10-13 September 2017 and a selection displayed at the Gallery Kopio, University of Lapland, Finland from July to September 2017.

Substrate	Average Hue Shift	Average Saturation Shift	Average Brightness Shift
Wool	Reduced by 4 degrees	Reduced by 18.5 %	Reduced by 29 %
Linen	Increased by 3.5 degrees	Reduced by 26.5 %	Reduced by 24 %
Cotton	Increased by 3 degrees	Reduced by 30 %	Reduced by 20 %
Silk	Reduced by 4 degrees	Reduced by 25.5 %	Reduced by 24 %

Table 1: Median Hue, Saturation and Brightness value shift by substrate.

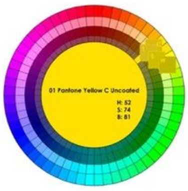

Figure 2: Gooby, B, 2017 Example of a Colour Map (Researcher's own collection) An example of a digital colour map. The hue circle is divided into 6 degree segments beginning at red 0/360 degree through to tones of magenta from 300 degrees and the rings decrease in saturation (S) and brightness (B). In this example the centre is filled by the screen colour with its original HSB values, and the digital versions of the fabric swatches placed around the outside to indicate HSB shifts.

Finally, the median HSB value shifts were applied to an RGB colour target which was subsequently measured to create an indicator display profile to imply substrate colour shifts to the viewer. The target file was edited in APCC to apply an overall median HSB adjustment (Table 1) for each substrate and then printed onto Cotton Satin. Cotton Satin has a tight weave and smooth surface and proved to have good colour results in previous experiments.

Figure 3: Gooby, B, 2018 AVA CAD CAM 1748 RGB Colour Target and the four adjusted targets L-R (Researcher's own collection).

The targets were measured with an Xrite EyeOne Profiler Spectrophotometer to create an ICC Profile. The Profile Maker Software used was AVA CAD CAM's Printer Cal and the colour target selected consisted of 1748 colour swatches. The profiles were then assigned to a specifically created colour test collage image file in APCC to observe the subsequent colour changes on screen. Profiles were further compared using Apple's ColourSync Utility with two standard generic ICC profiles, Adobe RGB (1998) and sRGB IEC61966-2.1.

RESULTS AND DISCUSSION

Figure 4: Gooby, B, 2018 Colour Collages with assigned profiles. Top Row L-R Wool, Linen, Silk. Bottom Row L-R Cotton, sRGB IEC61966-2.1, Adobe RGB 1998 (Researcher's own collection).

Six colour collages images were produced, four images with assigned indicator profiles (wool, linen, cotton, silk), and the additional two assigned standard, generic ICC profiles (sRGB IEC61966-2.1 and Adobe RGB 1998) as a comparable (Figure 4). Visual analysis observed subtle colour differences between the appearance of the six images.

Wool: The image had a slightly orange appearance which was most noticeable in the neutral colour ranges. The colours appeared muted in comparison with the images assigned with standard generic profiles. Colours from the blue/magenta tonal ranges were most vivid and green tones appeared bluer. The neutral ranges had a soft contrast and appeared to have a sepia like appearance.

Linen: The image had a slightly yellower appearance which was most noticeable in the neutral colour ranges and in the red tones. Blue and green tonal ranges appeared yellower. Neutral tones had a strong contrast but instead there was a loss of tone quality.

Silk: The image had a slightly magenta appearance which was most noticeable in the neutral colour ranges. The red tonal ranges appeared strong and spectral colours are saturated. Neutral ranges appeared darker than the linen or wool images, with a strong contrast.

Cotton: The image had a slightly orange-red appearance but neutral ranges did not. The colours were strong and saturated similar to the silk profile except that there was improved tonal quality and decreased contrast which achieves a better colour balance.

sRGB IEC61966-2.1: The image had strong saturated colours in comparison to the indicator profiles with no apparent overall colour tint. The neutral ranges had a slight green quality to them but contrast, tonal quality and colour balance were all good.

Adobe RGB 1998: The image had incredibly strong saturated colours, particularly in the blue tonal ranges, in comparison to the indicator profiles with no apparent overall colour tint. There was strong contrast but a lack of tonal quality. The neutral ranges had no apparent colour tint.

The underlying tints in the indicator profiles may be a consequence of adjusting the hue values, moving hues around the colour circle. The wool indicator having an orange tint is in keeping with the natural yellow of unbleached wool and therefore provides a good indication of colour changes. The yellow and magenta appearances of the Linen and Silk however do not match visual observations of printed colour from the colour reference book and would need to be corrected. The orange-red appearance of the Cotton shows that stronger red hues can be achieved when printing onto Cotton substrates as does the increased saturation in colours in the Silk profile. All indicator profiles demonstrated a loss of brightness and saturation in comparison with the standard, generic profiles which is true for printed colour. User testing of these indicator profiles would be required to demonstrate if they are a useful tool for designers.

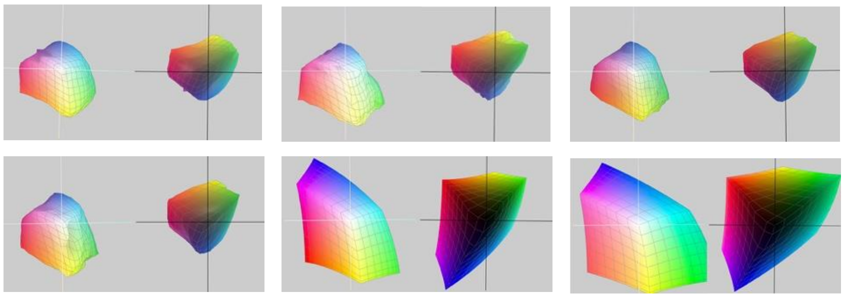

Figure 5: Gooby, B, 2018 Apple ColourSync Screen Grab Profile comparisons viewed from lightest and darkest points. Top Row L-R Wool, Linen, Silk Bottom Row L-R Cotton, sRGB IEC61966-2.1, Adobe RGB 1998 (Researcher's own collection).

Comparisons in Apple's ColourSync Utility showed that the gamut of the four indicator profiles was considerably smaller than the standard, generic profiles (Figure 5). The Wool indicator profile had the smallest achievable gamut and Linen the largest. The Linen indicator profile extended to the palest of shades whereas the Silk indicator profile achieved the darkest colour ranges of the four.

These results had some correlation with the findings of visual analysis of the colour reference book. Linen, a cellulose fibre constructed from flax plants, does not absorb dye particularly well. The juniper linen tested has the loosest weave of all four substrates and whilst colour matches on linen appeared good, the saturation was greatly reduced. Wool is a keratin protein, animal fibre which naturally repels moisture but does absorb dyes. However whitening pre-treatments are complex and wool in its natural state has a yellow undertone which affects the printed colour. Similarly, silk is an animal fibre and absorbs dye well. The smooth texture and reflective qualities of the satin silk tested provided strong colour results but darker than the screen colour. Cotton is cellulose, derived from cotton plants, but absorbs and retains dye well. Like the silk, both the linen and cotton were bleached white in the preparation for print.

CONCLUSION

The research presents three visual indications of colour changes when digitally printing to textiles for a designer to utilise, allowing them to make adjustments to design work in order to obtain a better colour match and develop their colour expectation knowledge; a colour reference book, digital lap dip tests with corresponding HSB values and indicator ICC profiles. The colour reference book may be used to look up different colours to determine how they might be expected to print. The digital lap dip tests provide an indication of how a colour might alter in hue, saturation and brightness when printed upon different textile substrates. The indicator ICC profiles offer a means of obtaining an overall sense of colour shifts when printing upon different substrates. The research project will develop these further to focus colour target adjustments on particular tonal ranges such as problematic neutrals, including greyscale ranges, as well as magenta and blue hues to determine whether isolating these ranges provides a more accurate reflection of colour printing issues.

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Travel journal (in colours) of Lisbon city

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ABSTRACT
In May 2016, the author made a two-week trip to Lisbon in the context of an internship. The purpose of the trip was to develop a colour study in three different and representative quarters of Lisbon: Alfama, Baixa and Chiado. Upon arriving in Lisbon, she took photographs, made colour sketches, wrote comments, interviewed different stakeholders –including architects, artists, and random tourists– and visited the library and book stores. While the original goal of the colour study was to develop a chromatic chart of the colours in these three neighbourhoods, things didn't go as planned. After walking day by day through the streets trying to grasp its chromatic atmosphere, internal reflections reoriented the purpose of the study which now aims at representing the colours of Lisbon.

Keywords: *Travel Journal, Lisbon, Neighbourhoods.*

INTRODUCTION

In May 2016, the author made a two-week trip to Lisbon in the context of an internship funded by the Chilean Ministry of Education and the Faculty of Architecture of Universidad Austral de Chile. The trip's aim was to visit the LabCor Lab in the Faculty of Architecture of the University of Lisbon, learn about the PhD. Program on colour, and develop a colour study in three different and representative quarters of Lisbon: Alfama, Baixa and Chiado.

Since she had never been in Lisbon and knew nothing about the city, she decided to read three books and watch three films as a preliminary approach to its features. The films were "Night train to Lisbon", "Stories about Lisbon" and "In the white city". The books were "Afirma Pereira" and "Requiem" by Antonio Tabucchi, and the chapter about Lisbon of "Trip to Portugal", by Jose Saramago. These sources gave her a picture of Lisbon as a white city. Once in Lisbon, she started her colour study using the same methodology she had used in her former research about three quarters in the city where she lives, Valdivia, Chile. Early on, she decided to change the methodology; the issues she faced led to very different results.

THEORY

According to Michel Onfray (2016), a journey begins with the will to travel. The author defines several steps, from the beginning to the traveling experience itself to its end, which shapes up the experience and its eventual continuation. One of the intermediate steps is to "trap memory", where a traveller leaves his/her impressions in any supporting media. This medium could be a photograph, a sketch, a watercolour painting, a poem or a sound recording. Such traces, more than justifying the voyage, make it partially immortal (p.59).

When collecting the trip in different mediums, the traveller experiences his/her daily life and reflects upon it in an attitude of open curiosity and honest awe, which distinguishes him/her from a regular tourist who goes on a pre-set itinerary, since "traveling is discovering, the rest is simply finding" (Saramago, 1998). This traveling in constant awe is also a trip to the traveller's internal space –along with his/her physical trip– "which helps either in growing or self-destruction, or getting to know ourselves or expressing the conflicts in which we live" (Zamudio, 2004). When returning home, there is a need to revisit and organize the information collected which takes the experiences lived through a second lens; "for the trip to gain meaning, it has to go through a fixation or understanding process" (Onfray, 2016).

The artist's travel dairy format is rooted in history. The sketchbook by medieval architect and traveller Villard de Honnecourt has detailed drawings of constructions and human figures, but no mention to colour. In the 19th century, Eugene Delacroix travelled to Morocco where he created a diary with a dedicated chromatic study in the form of watercolour drawings. Le Corbusier, in his trip to the East, carried notebooks where he sketched his impressions, some of them in colour.

The onsite register of a city's architecture and public spaces has a recording language which usually involves sketches and photographies. However, the need to show colour in architecture at a later phase of the registration process broadens the graphic range to other more elaborate representation formats, among them planimetry, perspectives or collages, such as those made by Aldo Rossi, Steven Holl or Sauerbruch and Hutton. How many ways are there of representing the colour of architecture and of a city?

EXPERIMENTAL

For the colour study, the author interviewed different people about the colour of the city, including architects, artists, the owner of a bookshop and random tourists. She also found and reviewed very interesting books about Lisbon, which helped her figure out the insights, reflections and statements made by writers, artists and experts about the colours of the city of Lisbon.

RESULTS AND DISCUSSION

In spite of the fact that the three quarters chosen have distinct urban and chromatic atmospheres, none of them is white, as though in the beginning. The colours that caught the initial attention of the author were pink, aquamarine and Azulejo blues for their chromatic complexity and brightness.

To simplify the study and given the short time available, the author selected one representative street by quarter that included a plaza. In Baixa, she chose Calçada do Combro, starting at Largo Dr. António de Sousa Macedo up to Praça Luís de Camões. In Barrio Alto, she chose Rua da Prata between Praça da Figuieira and Praça do Comercio. In Alfama, in Moreria, she took Largo da Achada, between Rua do Castelo and Rua São Cristóvão. In spite of the fact that the original goal of the colour study was to develop a chromatic chart of the colours of these three districts, things didn't go as planned.

The internal reflection, resulting from walking every day through the streets attempting to capture their chromatic atmosphere, reoriented the purpose of the study, which now focused on how to represent the colours of Lisbon. Some drawings and diagrams were made on site (Figure 1).

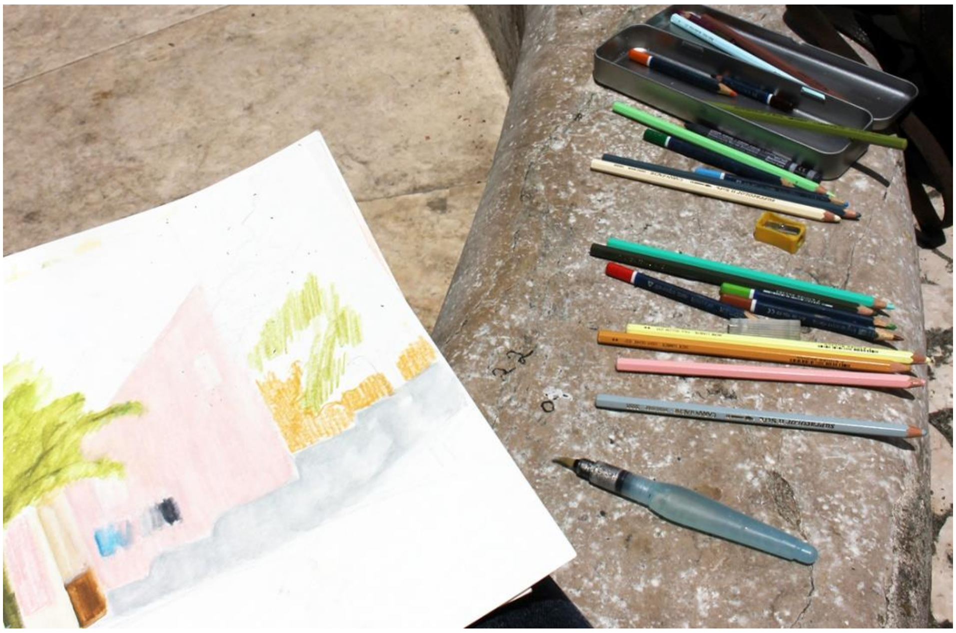

Figure 1: Largo da Achada. Painting with watercolour on site (2016).

However, upon returning home, she began investigating the modes of representation of architecture and of the city, to cross reference them with the material collected during her internship (Figure 2).

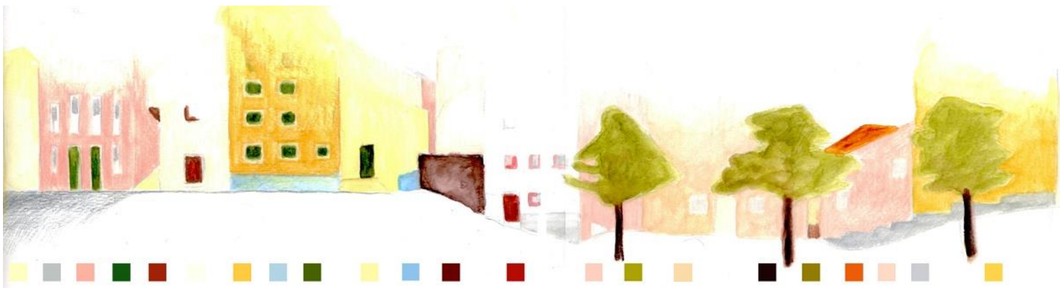

Figure 2: Largo da Achada. Drawing and watercolour.

Presented as a travel journal, this study is a work in progress and an account of the author's efforts to represent, through graphic schemes, impressions, diagrams, charts, collages, perspectives and drawings, the colours she found.

CONCLUSION

Experiencing colour in a city is a subjective practice. How to convey that experience to others – regardless if they are colour experts– is something to be reflected upon. This study is a graphic proposal on this issue, which nevertheless remains open to further discussion.

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colour & human comfort

Characteristics of the Tooth Crown Colours of People in Fashion Magazines

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ABSTRACT

The spectral reflectance factor of the maxillary central incisor region of portrait photographs published in fashion magazines sold in Japan was measured, and its diversity was analysed by principal component analysis. The results were summarized as the first principal component, which is correlated with lightness; second principal component, which is correlated with the degree of yellowness; and third principal component, which is correlated with the fluorescent whitening intensity of a printing paper. The crown colour of maxillary central incisors of Japanese university students was measured and compared with that of individuals in photographs printed in fashion magazines. The results indicated that the tooth crown colour in photographs printed in fashion magazines had an extremely low degree of yellowness, contrary to that observed in natural teeth. Because readers usually accept this nonexistent tooth crown colour to be true, they believe or desire that the natural tooth crown colour also has an extremely low degree of yellowness.

Keywords: *Aesthetic Dentistry, Tooth Crown Colour, Fashion Magazine, Principal Component Analysis, Natural Tooth*

INTRODUCTION

The demand for aesthetic dentistry focusing on the cosmetic aspects of teeth, such as crown whitening and orthodontic treatment, rather than oral treatment has been increasing (Tsubaki, 2018). This may have been caused by the reduction in the number of patients with caries due to increasing awareness of oral hygiene and the dissemination of information on oral aesthetics by the mass media. The principal aims of the present study were to measure the tooth crown colours of individuals in photographs printed in fashion magazines and spectroscopically analyse and compare them with those of natural teeth, thereby clarifying their features.

EXPERIMENTAL OUTLINE

We measured the spectral reflectance factor of the maxillary central incisor region in portrait photographs (204 female and 64 male) in fashion magazines sold in Japan, which principally targeted readers in their 20s. Most subjects in the portrait photographs analysed were Japanese. A spectrodensitometer (FD-7, Konica Minolta) was used to perform the measurements. The measurement wavelength range was 380–730 nm, wavelength interval was 10 nm, and measurement diameter was 3.5 mm. In fashion magazines, close-ups of female faces are frequently encountered in beauty-related articles, whereas males are shown in full-body photographs. Therefore, there were only a few male photographs with crown diameters of >3.5 mm. Therefore, photographs of females comprised the majority of the measurement targets.

Next, a dental colorimeter (Easyshade® Advance, VITA) was used to measure the crown colour of the maxillary central incisors of 97 Japanese university students (48 female and 49 male; mean age, 20.6 years; standard deviation, 1.46 years). The measurements were performed in triplicate. The maxillary central incisors of all the subjects had no dental caries, fillings, or discolouration and were in a healthy state, without significant orthodontic correction. Prior to the measurement of the crown colour, the subjects were instructed to remove any impurities on the crown surface using a disposable tooth brushing paper.

RESULTS AND DISCUSSION

In all the photographs of individuals in fashion magazines, colours were reproduced by planographic printing using process ink. The spectral reflectance factors of the region corresponding to the maxillary central incisors in portrait photographs of the 268 females and males are summarized in Figure 1. The comparison of the mean reflectance factor at each wavelength according to gender revealed no significant difference at any wavelength. Principal component analysis (Abdi and Williams, 2010) of the spectral reflectance factors revealed that the contribution ratios of the first, second, and third principal components were 88.04%, 6.02%, and 4.27%, respectively, and the cumulative contribution rate of the components was 98.33%. The wavelength characteristics of each principal component vector are shown in Figure 2. Evaluation of the relationship between the principal component score and colorimetric value of each tooth crown colour revealed a significant correlation between the first principal component score and L^* value, second principal component score and yellowness index (*YI*) (ASTM, 2001), and third principal component score and fluorescence intensity (differences between the D65 brightness (ISO, 1993) values in the presence and absence of the UV component) as shown in Figure 3. These results demonstrated that the diversity of the spectral reflectance factor of the tooth crown colours in portrait photographs in fashion magazines can be explained by the lightness, degree of yellowness, and fluorescent whitening intensity of the printing paper.

Subsequently, the crown colour of natural teeth and that of photographs in fashion magazines were colorimetrically compared. A standard illuminant D65 and standard colorimetric observer CIE 1931 were used for the calculation of colorimetric values. The mean values of L^*, C^*_{ab}, a^*, b^*, and *YI* for the natural teeth revealed no significant differences based on gender. Figure 4 shows a^* b^* colour coordinates of the crown colour of the 97 natural teeth and the 268 teeth from photographs in fashion magazines. The ellipse in the figure is a 95% confidence ellipse. The crown

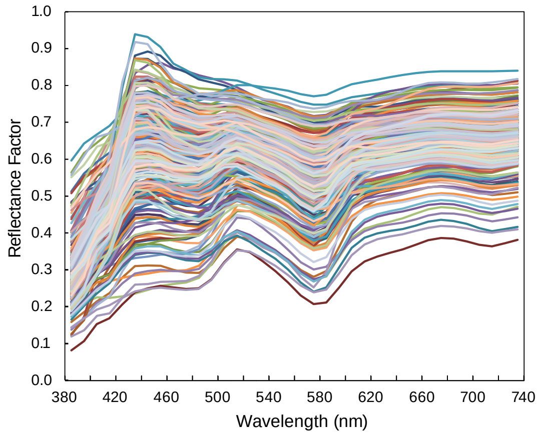

Figure 6: Spectral reflectance factors of crown colour in fashion magazine photographs.

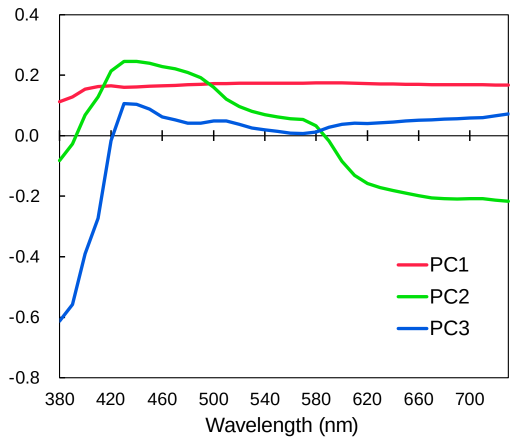

Figure 2: Wavelength characteristics of each principal component vector.

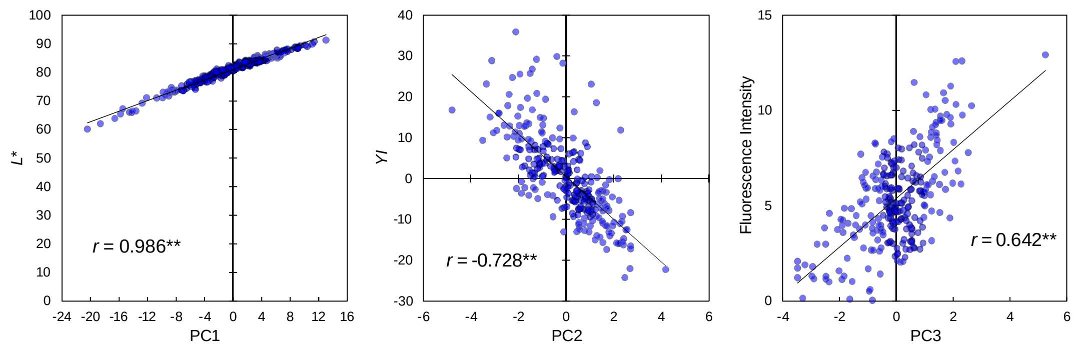

Figure 3: relationship between the principal component score and colorimetric value of each tooth crown colour.

colours of teeth in fashion magazines were mainly distributed around the coordinates (a^*, b^*) = (1.7, −0.5), which was the area near the achromatic point, whereas the crown colours of natural teeth were mainly distributed around the yellow region, with coordinates (a^*, b^*) = (−0.7, 17.5). The L^* and C^*_{ab} values of the crown colours of natural teeth and those in fashion magazines are shown in Figure 5. The ellipse in the figure is a 95% confidence ellipse. The lightness of the crown colour of teeth in fashion magazines was considerably higher than that of natural teeth, and their chroma was considerably low (Fig. 5). The crown colours of natural teeth and those of teeth in fashion magazines were compared in terms of lightness, chroma, and yellowness; the results indicated that the tooth crown colour in fashion magazine photographs had significantly higher lightness but significantly lower chroma and yellowness than those of natural teeth as shown in Figure 6. The colour difference, ΔE_{00} (CIE, 2011) between the mean values of the crown colour of natural teeth and those in fashion magazines was 14.1. These findings indicated that fashion magazines show tooth crown colours with an extremely low degree of yellowness, which is not observed in case of natural teeth. However, because the readers of fashion magazines usually accept this unnatural tooth crown colour to be true, they perceive that the ideal crown colour is the one with a very low degree of yellowness.

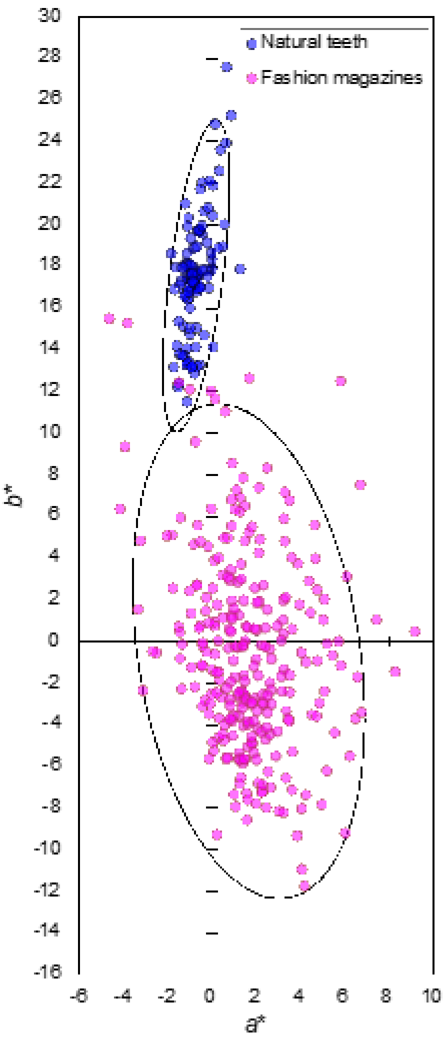

Figure 4: a^* b^* color coordinates of the crown color of the 97 natural teeth and the 268 teeth from photographs in fashion magazines

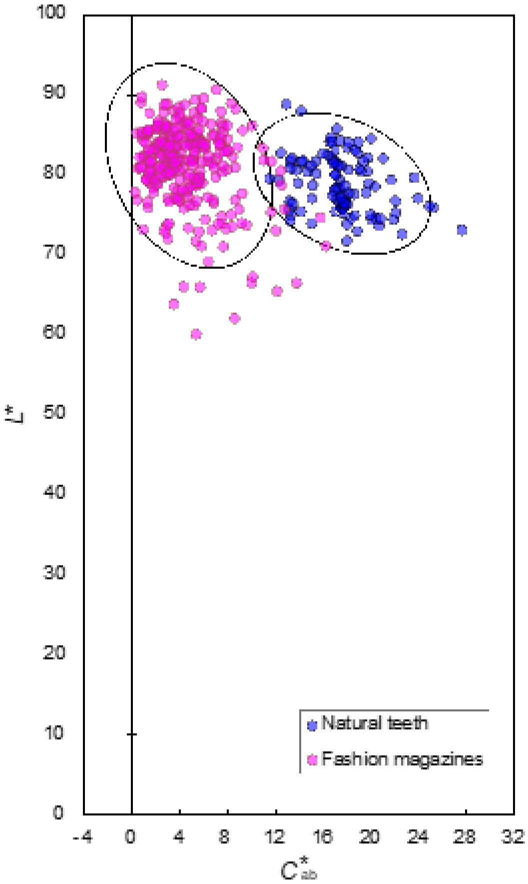

Figure 5: L^* and C^*_{ab} values of the crown colors of natural teeth and those in fashion magazines

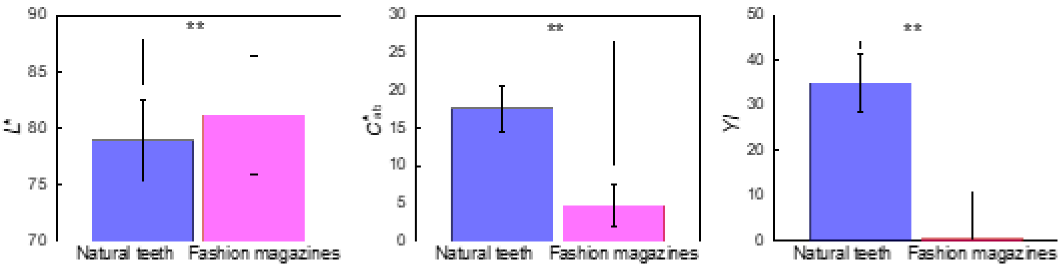

Figure 6: Comparison of colorimetric values between natural teeth and teeth in fashion magazines

SUMMARY

The results revealed that the diversity of the spectral reflectance factor observed in the crown colour of teeth in fashion magazine photographs can be explained by the lightness, yellowness, and fluorescent whitening intensity of the printing paper and the fact that it has extremely low degree of chroma and yellowness compared with natural teeth. As readers of fashion magazines usually accept this non-existent tooth crown colour as real, they assume it to be the ideal tooth crown colour.

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A Study on the Proposal of Personal Colour Fashion Material Pattern

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ABSTRACT

The 21st century is an era of personality and emotion, and the interest in personal colour is increasing accordingly. In this study, to increase the utilization of personal colour in the fashion industry field, first, we examined the linguistic image and fashion material pattern according to the personal colour type through the preceding study. Second, we analysed the difference in linguistic image evaluation between fashion and non-expert group. Third, we investigated the relationship between the pattern of fashion material and the linguistic image of the type of personal colour through the questionnaire. Fourth, the effect of colour on the proposal of personal colour fashion material pattern was examined. Through this research, I will make a new proposal for research on personal colour and fashion material pattern.

Keywords: *Personal colour, fashion material pattern, material suggestion, fashion, material colour*

INTRODUCTION

The 21st century is an era in which people want a customized service that is appropriate for their own needs. At the same time, interest in colour has increased as the era of emotion, and the age of image has entered the era (Choi, Nayoung, 2012). Personal colour preliminary studies focus on visual diagnosis, or studies on hair dyeing, makeup, and psychology. However, even though fashion is one of the most important elements of image formation, research on the personal colour- fashion field is inadequate. Therefore, in this study, to increase utilization of personal colour in the fashion industry field, first, we investigate the linguistic image and fashion material pattern according to the type of personal colour through previous research. Of the linguistic image by types of fashion material pattern of the expert group and non-expert group is grasped. Third, the relationship between the fashion material pattern and the linguistic image of the type of personal colour is analyzed through the questionnaire. Fourth, we examine the effect of colour on the proposal of personal colour fashion material pattern. Based on the previous studies, (Jackson, C., 1980; Yeo, Sang-mi, 2006; 2007; Choi, Nayoung, 2012; Kim, Hyojin, 2017) we extracted 8 kinds of language images (floral pattern, small pattern, gingham check, curve, fan stripes, small water drops, Leopard, paisley, tartan check, geometry, block stripes) and selected 12 patterns of fashion material.

EXPERIMENTAL

Based on the previous research, we conducted the first questionnaire to understand the relationship between the selected patterns of fashion material and verbal images. We used a black and white pattern using Adobe Photoshop CC 2017 to see only the influence of the pattern. The questionnaire consisted of a total of 99 items, including 12 items, followed by a 5 - point scale for language images, and basic personal information (3 questionnaires). The demographic characteristics of the respondents were 11 (23.4%) and 36 (76.6%), respectively. The age group was 32 (68.09%) in their 20s, 14 (29.79% %). To compare and analyse the professional group and the non-expert group, the occupational group of the subjects were divided into fashion, beauty, colour related profession and other occupations. 24 persons (51.06%) were in the expert group, and 23 persons (48.94%) were in the other occupations. To investigate the effect of colours on the proposal of personal colour fashion material pattern, four patterns (flower- spring, silk plain-summer, tartan Check- fall, block stripe - winter) were selected and used in the second questionnaire. As a result of the first questionnaire, the pattern of the personal colour - summer season was not selected. For the second questionnaire, a suitable silk plain pattern was selected as the summer pattern of the second questionnaire. <Table 1> shows the language image and fashion material pattern for each type of personal colour used in this study.

Used Survey	Item	Season	Language images and fashion material pattern items, etc.
1st Survey 2nd Survey	Image of Language (8 kinds)	Spring	girlish, Pretty
		Summer	feminine, elegant
		Autumn	classic gorgeous
		Winter	Chic, modern
1st Survey	Fashion material pattern (12 kinds)	Spring	Flower pattern, small pattern, gingham check pattern
		Summer	Curved pattern, fan-striped pattern, small droplet pattern,
		Autumn	Leopard pattern, Paisley pattern, Tartan check pattern
		Winter	Geometric patterns, block stripe patterns, plain patterns
2nd Survey	Fashion material pattern (8 kinds)	Spring	Flower pattern (Yellow/Blue)
		Summer	Silk plain pattern (Yellow/Blue)
		Autumn	Tartan check pattern (Yellow/Blue)
		Winter	Block stripe pattern (Yellow/Blue)

Table 1: Language images and fashion material patterns by personal colour type.

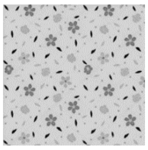
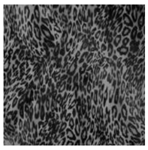
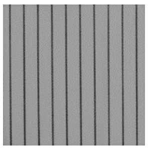
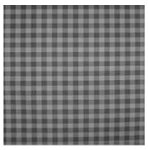
To understand the influence of colours, the second questionnaire was used to convert four patterns of seasonal fashion material extracted from the first questionnaire and previous research into two colours using Adobe Photoshop CC 2017. The colours were selected as yellow, blue, and hue, which are representative colours of warm tone / cool tone of personal colour. As with the first questionnaire, the linguistic image was evaluated on a 5-point scale, and a total of 66 items including basic personal information (2 items) were administered. The demographic characteristics of the second questionnaire were 15 men and six women (40%) and nine women (60%). The age group was the highest with 20 persons (67%), 20%) and two persons in their 50s (13%). Data from the questionnaires collected and their mean values were used for frequency analysis, F-test, and t-test.

RESULTS AND DISCUSSION

The relationship between group fashion material pattern and language image

F-test results showed no significant difference between the two groups (expert group, non-expert group) (F = 1.323, n.s.). Based on the results of the F-test, it was confirmed that there was a very similar evaluation tendency (t = -0.483, n.s.) with no significant difference between the two groups. Since there was no difference in the evaluation tendency between the two groups, the subsequent analysis was analyzed as the mean value between the two groups.

The relationship between fashion material pattern and language image

패턴명	Fashion material pattern	Language image	Season	Overall average	Pattern name	Fashion material pattern	Language image	Season	Overall average
Flower pattern		Girlish	Spring	3.152	Leopard pattern		Girlish	Spring	2.261
		Feminine	Summer	3.348			Feminine	Summer	2.565
		Classic	Fall	2.522			Classic	Fall	2.109
		Chic	Winter	1.587			Chic	Winter	3.283
		Pretty	Spring	3.500			Pretty	Spring	1.826
		Elegant	Summer	2.304			Elegant	Summer	2.783
		Gorgeous	Fall	2.000			Gorgeous	Fall	3.130
		Modern	Winter	1.957			Modern	Winter	2.196
Pencil stripe pattern		Girlish	Spring	1.804	Geometric pattern		Girlish	Spring	1.739
		Feminine	Summer	2.087			Feminine	Summer	2.022
		Classic	Fall	3.609			Classic	Fall	1.978
		Chic	Winter	3.630			Chic	Winter	2.543
		Pretty	Spring	1.696			Pretty	Spring	1.587
		Elegant	Summer	2.152			Elegant	Summer	2.065
		Gorgeous	Fall	2.022			Gorgeous	Fall	2.522
		Modern	Winter	3.913			Modern	Winter	2.543
Paisley pattern		Girlish	Spring	1.935	Gingham check pattern		Girlish	Spring	2.152
		Feminine	Summer	2.761			Feminine	Summer	2.217
		Classic	Fall	3.152			Classic	Fall	3.391
		Chic	Winter	2.174			Chic	Winter	2.413
		Pretty	Spring	1.870			Pretty	Spring	2.022
		Elegant	Summer	3.391			Elegant	Summer	1.935
		Gorgeous	Fall	3.435			Gorgeous	Fall	1.935
		Modern	Winter	2.065			Modern	Winter	3.283
Block stripe pattern		Girlish	Spring	2.022	Curved pattern		Girlish	Spring	1.935
		Feminine	Summer	2.174			Feminine	Summer	2.500
		Classic	Fall	3.217			Classic	Fall	2.435
		Chic	Winter	3.630			Chic	Winter	2.891
		Pretty	Spring	1.783			Pretty	Spring	1.870
		Elegant	Summer	2.413			Elegant	Summer	2.674
		Gorgeous	Fall	2.196			Gorgeous	Fall	2.609
		Modern	Winter	3.761			Modern	Winter	3.304

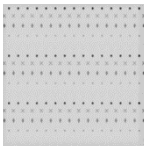
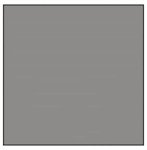
small pattern		Girlish	Spring	2.174	Tartan check pattern		Girlish	Spring	2.261
		Feminine	Summer	2.196			Feminine	Summer	2.239
		Classic	Fall	2.370			Classic	Fall	3.696
		Chic	Winter	2.087			Chic	Winter	3.000
		Pretty	Spring	2.543			Pretty	Spring	1.957
		Elegant	Summer	2.000			Elegant	Summer	2.304
		Gorgeous	Fall	1.826			Gorgeous	Fall	2.304
		Modern	Winter	2.304			Modern	Winter	3.196
Small polka dots pattern		Girlish	Spring	2.283	Plain pattern		Girlish	Spring	2.217
		Feminine	Summer	2.370			Feminine	Summer	2.783
		Classic	Fall	3.239			Classic	Fall	3.674
		Chic	Winter	2.978			Chic	Winter	3.457
		Pretty	Spring	2.391			Pretty	Spring	2.261
		Elegant	Summer	2.348			Elegant	Summer	3.130
		Gorgeous	Fall	2.239			Gorgeous	Fall	2.826
		Modern	Winter	3.217			Modern	Winter	3.957

Table 2: Relationship between fashion material pattern and language image.

As shown in <Table 2>, the average value of flower pattern (3.50) and small pattern (2.54) showed the highest average value in Pretty-Spring, and it became a fashion material pattern of spring. In the block stripe (3.76), ignorance (3.95) and geometry (2.54), the average values were the highest in the modern - winter and chic - winter, respectively. The average value of winter was the highest in the Pencil stripe (3.91) and curved pattern (3.30), but this is not the same as that reported by Choi, Na Young (2012) in the summer fashion pattern. In Leopard (3.28), the overall average value was chic - the highest value in winter, and it appeared as a winter fashion pattern. It is different from the one that Choi, Na-young (2012) said in a spring pattern, and Yeo, Sangmi (2007) in autumn. In Paisley (3.43) and Tartan Check (3.69), the overall average value was highest in the Gorgeous-Autumn and Classical-Autumn, respectively, and showed a pattern of autumn fashion. In the small water drop (3.23), the average value was the highest value in the classical-autumn, and it became the fashion material pattern of autumn. This is the result of research that is different from what Choi Nam-young (2012) described as a pattern of spring, and Soo-mi (2007) as a pattern of autumn. In the gingham check (3.39), the overall average value was the highest value in the classical-autumn period, and it became a fashion material pattern in autumn. This is a result of research that is not consistent with that reported in the spring pattern in the research of Yeo, Sang Mi (2007).

The effect of colours on the relationship between personal colour season and fashion material pattern

The results of Table 3 show that the flower pattern has the highest average value in Girlish (3.60) and Pretty (3.40) irrespective of colour, and it is a spring pattern. This is consistent with the results of the first experiment. It can be suggested that a flower pattern can be proposed as a spring pattern regardless of colours when a personal colour fashion material pattern is proposed. Silk plain patterns also showed the highest average value of the elegance regardless of colour. The silk plain pattern can also be suggested to the person of the summer season regardless of the colour when suggesting the fashion material pattern of the personal colour. In the case of the tartan check pattern, the tartan check pattern of blue colour appeared as the fashion material pattern of autumn as the result of the first survey, but the tartan check pattern of yellow colour appeared as the fashion material pattern of winter. It can be seen that the tartan check pattern can affect not only the pattern but also the colour. In the case of the block stripe pattern, the result of the first fashion survey, which excluded the colour, came out as winter fashion material pattern. However, the result of the experiment with the block stripe pattern of blue and yellow colour was obtained as a result of the fall fashion pattern. This suggests that when suggesting a fashion material pattern in personal colour, it can be proposed variously not only by pattern but also by colour, and it is understood that a pattern and a colour should be presented complexly when a pattern is proposed.

		Flower pattern		Silk plain pattern		Tartan check pattern		Block stripe pattern	
season	Language image	Blue medium	Yellow medium	Blue medium	Yellow medium	Blue medium	Yellow medium	Blue medium	Yellow medium
spring	Girlish	2.53	3.60	2.20	3.20	1.80	2.47	1.80	1.87
summer	Feminine	3.00	3.33	2.33	3.33	2.07	2.20	2.00	1.93
autumn	Classic	2.00	1.93	3.00	2.93	3.33	2.80	3.40	3.33
winter	Chic	1.93	1.60	3.20	2.13	2.67	2.20	2.67	2.60
spring	Pretty	2.93	3.40	2.13	3.13	2.00	2.27	1.93	2.13
summer	Elegant	2.27	2.20	3.47	3.60	2.27	2.13	2.33	2.20
autumn	Gorgeous	1.87	2.07	3.13	3.07	2.40	1.93	2.33	2.07
winter	Modern	2.13	2.07	2.73	2.67	2.93	3.13	3.20	3.07

Table 3: Colour and Fashion Material Patterns - Relationships with Language Images.

CONCLUSION

The results of this study are as follows: 1) Through previous studies, we have selected 8 kinds of language images (girlish, feminine, classic, chic, pretty, elegant), and 12 kinds of fashion material patterns (flowers, small patterns, gingham check, curves, fan stripes, small water drops, Leopard, paisley, tartan check, geometry, block stripes) as a result of studying the linguistic image and fashion material pattern according to the type of personal colour.

2. F-test and t-test were conducted to identify the relationship between the fashion material pattern and language image between two groups of experts and non-experts. There was no significant difference between the two groups. It can be seen that not only the expert group but also the general person group can feel the linguistic image of the fashion material pattern and the general person can sympathize with the fashion material pattern suggested by the expert.

3. There was also a personal colour type which was consistent with the previous study, but the pattern of fashion material which is not consistent with the previous study was also derived. This can be seen from the lack of empirical precedent research that was made by analysing the linguistic image and fashion material of personal colour.

4. The effect of colour on the proposal of personal colour fashion material pattern is examined. As a result, not only the material pattern but also the colour is an important factor for determining seasonal personal colour pattern according to pattern type. In the case of a personal colour fashion material pattern proposal, it should be noted that the pattern and the colour should be presented.

5. The result of this study is a new proposal in the field of personal colour and fashion material pattern which is valuable as basic data to suggest fashion material pattern in personal colour diagnosis. However, the selection of materials may be limited in this study, but future research using various fashion material patterns can be expected.

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The Influence of Texture and Gloss upon Colour Emotions and Colour Harmony of Three Dimensional Shape

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ABSTRACT

In order to see the influence of texture and gloss upon colour harmony of two-colour combinations, this study planed a psychophysical experiment. The experiment provided a series of colour-finishing combinations to collect the data of colour emotion and colour harmony by using visual assessment. Each colour-finishing combination was produced by 7 colours together with three finishing appearances, including matt, glossy and sand. In total 441 colour-finishing combinations were produced. The participants were invited to assess experimental sample on 4 scales including "active-passive", "heavy-light", "warm-cool" and "harmonious- disharmonious". The results showed that the different finishing have different impact on different emotion scales.

Keywords: *Product design, Colour emotion, Colour harmony, Texture, Gloss*

INTRODUCTION

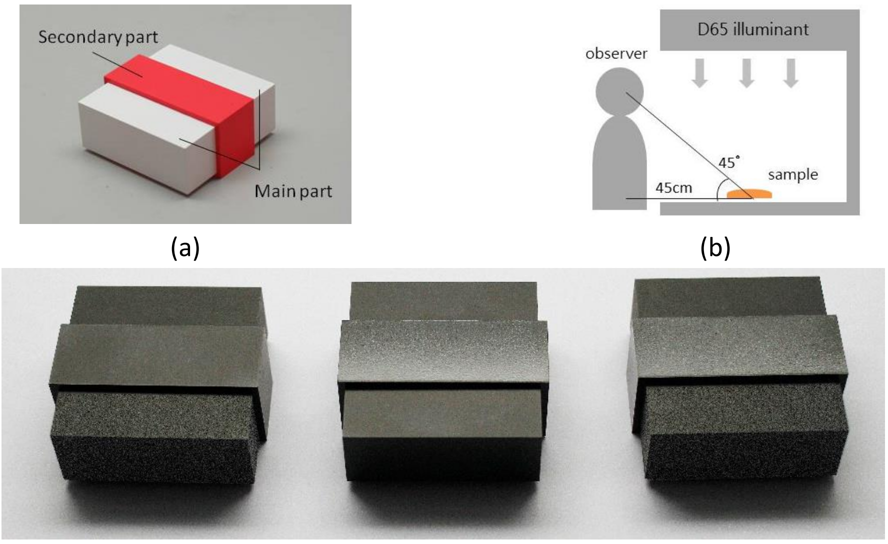
In the process of creating appearance of product, designers not only deal with colour, but also texture and gloss on the appearance of product. How to create an eye-catching appearance of product is a great challenge for designers. Many studies[1-15] have been studied on colour harmony and colour emotion, however, the results obtained from these studies were considered as impractical for product design. Because these studies only used 2D colour samples as experimental sample, the designers always deal with the three-dimensional shapes, even the colour configuration appeared more complexity than those in literatures. In addition, for colour design, designers need to know how texture and gloss affect the colour harmony. If the texture and gloss can be involved in the experiment of colour harmony, the results can give designers a comprehensive suggestion.

EXPERIMENTAL PLAN

In order to see the influence of texture and gloss upon colour emotion and colour harmony of two-colour combinations, a psychophysical experiment was conducted. The experiment provided a series of colour-finishing combinations to collect the data of colour emotion and colour harmony by using visual assessment. A side circle applied onto a cube shape was used as colour configuration of experimental sample. The main colour was applied onto a cube shape, secondary colour side circle shape, as shown in Figure (a). Seven colours and three finishing appearance were integrated together. Seven colours include black, grey, white, red, green, yellow and blue colours. Three finishing appearances include sand, matte and gloss. The colour-finishing combinations are demonstrated in Figure (c), the left sample uses sand finishing on main colour, matt on secondary colour; the middle sample uses matt on main colour, gloss on secondary colour; the right sample uses sand on main colour, gloss on secondary colour.

In total, 441 experimental samples were produced. Each sample was assessed on 4 scales by using 7-step categorical judgment. These 4 scales included “active-passive”, “heavy-light”, “warm-cool” and “harmonious- disharmonious”. Each experimental sample was displayed in a viewing cabinet and illuminated by a D65 simulator. The viewing distance was about 45 cm with a 0/45 illuminating/viewing geometry, as shown in Figure (c).

In order to prevent the fatigue caused by the long experiment, the Balanced Incomplete Block Design (BIBD) method was used for observers randomly assessing the experimental samples. Each experimental sample was judged by at least 30 observers. Totally 90 participants took part in the experiment.



(a) (b)

(c)

Figure 1: (a) experimental samples, (b) viewing geometry, (c) the experimental samples with different finishing

RESULTS

In order to see the influence of texture and gloss upon colour emotion and colour harmony of two-colour combinations, the mean results were used to rank colour combinations in order of colour emotion and colour harmony scales. **Error! Reference source not found.** summaries the top 10 samples along 4 scales. It can be seen that (1) colour was found to be the most influencing appearance attribute comparing to texture or gloss, (2) gloss attribute are not associate with "passive" emotion, reflecting that the "passive" emotion was evoked by sand or matt appearance, (3) top ten samples on "heavy", "cool" and "passive" emotions are associated with achromatic colours, the significant distinction is the gloss usage. In other words, the achromatic colour combinations with gloss tended to be "heavy" and "cool" emotions, those without gloss "passive."

On the base of ranking results, **Error! Reference source not found.** summarized the top sample of nine finishing combinations on 4 scales. In each diagram, horizontal axes represents 3 finishing appearance of main colour, vertical axes secondary colour. The combination in the middle of each diagram shows the colour combination using matt-matt finishing combination. Comparing to matt-matt finishing combination, the colour combination was found to be different, except on "heavy" emotion. This tells us that different finishing combinations affected the colour combinations on the two ends of emotion scales.

Furthermore, to reveal the integrated relationship between main finishing and secondary finishing, the line chart was illustrated based on Lazreg and Mullet's [16] suggestion, as shown in **Error! Reference source not found.**. In **Error! Reference source not found.**, the horizontal axes represent three types of finishing of main colour, vertical axes the standardized score of emotion values. Each line in **Error! Reference source not found.** represents the finishing of secondary colour. Four patterns[16] will reveal the relationship between main finishing and secondary finishing are additive or multiplicative on the emotions.

The results summarized below

(1) The "warm-cool" emotion was found not to be influenced by finishing on main and secondary colours, indicated by three lines appear horizontal and overlapped in **Error! Reference source not found.**(b)

(2) The three lines in **Error! Reference source not found.**(a)(c)(d) are not equally increase or decrease. This reflected that on the emotions of "active-passive", "heavy-light" and "harmonious-disharmonious," the relationship between main finishing and secondary finishing was multiplicative.

CONCLUSION

In the field of product design, CMF (Colour, Material and Finishing) design is getting more and more attention. The appearance of product includes colour, texture, gloss, etc. This study used three finishing applied onto main and secondary colour respectively, intending to see how the different finishing influence the colour emotion, which have been researched in many studies. The results showed that the different finishing have different impact on different emotion scales. Such preliminary results showed that the finishing impact are existed in the phenomenon of colour harmony and colour emotion, but this has to be confirmed by further research.

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Colour contrast in packaging and consumer product perception

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ABSTRACT

Visual stimuli such as packaging and colour play an important role in shaping consumers' perceptions regarding food products. A quantitative approach was used to explain the link between colour combinations (complementary *vs.* analogous colours) and consumers' perceptions on calories, healthiness and purchase intention. A questionnaire was conducted with 344 valid respondents who were asked to rate their perceptions regarding two different packages for cookies: one, blue and orange, and another, blue and green. The results demonstrated that the blue and orange packaging (complementary colour set) was perceived to be less healthy and more caloric. However, participants revealed a higher intention to purchase this package. Finally, managerial implications, limitations and future research directions are discussed.

Keywords: *Packaging, colour, food, calorie estimation, healthiness perception, purchase intention.*

INTRODUCTION

The ever-increasing competition forces marketers to find efficient strategies that may captivate potential customers. Some of these strategies involve product packaging and colour, which are crucial factors for a purchasing decision (Kazanjian, 2013; Mohebbi, 2014). Research has shown that visual engagement should be created, as consumers' decisions at the point of purchase are highly affected by package appearance, including colour (Gorn *et al.*, 1997).

As a consequence of the contemporary concern with a healthy lifestyle, consumers are increasingly more receptive to healthy food, specifically, food's caloric content (Dong, 2013). By using the symbolic meaning of colour as a valuable instrument, brands could develop their own strategies to enhance the intention to purchase a product. Different colours have different symbolic associations and, consequently, colour could be an excellent source of information for consumers (Bakker *et al*., 2013).

Colour research on packaging and consumer behaviour has mainly focused on single colour effects instead of colour combination effects. Bearing in mind that research concerning the effect of specific colour combinations is still scarce (Labrecque *et al*., 2013; Pridmore, 2011), the present study is focused on the effect of complementary and analogous colours applied in a hedonic category of products: cookies packaging. We analyse the consumers' expectations on calories and healthiness perception as well as their purchase intention.

THEORY

Approximately three-quarters of purchase decisions are made at the point of sale (Ampuero and Vila, 2006). According to Venter *et al*. (2011), the attributes of product packaging capture consumers' attention, thus working as a stimulus. Specifically, people start processing information to form perceptions. Package design comprehends three main dimensions: 1) graphic design; 2) structure design; and 3) product information (Cahyorini and Rusfian, 2011). Accordingly, the graphic design, which includes imagery, colour and typographic elements, is the most impactful dimension in impulsive buying. Furthermore, there is a positive relation between the ability of a package to draw attention and the subsequent product choice, when considering food products. In this sense, colour plays a determinant role in drawing consumers' attention (Singh, 2006).

Colour influences product perception, namely on healthiness (Huang and Lu, 2013), willingness to pay (Lajos and Chattopadhyay, 2011), and food taste (Huang and Lu, 2015). Additionally, colours have different symbolic associations. As an example, Singh and Srivastava (2011) have attested that red conveys excitement and power, and orange transmits heat and desire. Similarly, Crowley (1993) stated that a high wavelength hue is more arousing, and a low wavelength hue is perceived as more pleasant. Lajos and Chattopadhyay (2011) stressed that packages in a colour with a high wavelength hue are perceived to have greater volume than the ones using colours with low wavelength hues, and that willingness to pay is higher for packages using colours with high wavelength hues. Beneke *et al*. (2015) stated that purple is one of the most powerful colours in perpetuating brand loyalty, whereas orange is the one of the weakest.

As people are increasingly attentive to health issues and calorie intake (Koo and Suk, 2016), brands are interested in understanding consumer behaviour related to healthiness perception. Although food packages encompass full information on health and nutritional content, research suggests that consumers typically do not read this information (Cowburn and Stockley, 2005). Moreover, Vasiljevic *et al*. (2015) revealed that nutritional labels have a little impact on consumer's perceptions and no impact on consumer's choice of snack foods. Consequently, visual cues, such as colour, become critical when consumers form their perceptions about product healthiness and caloric content (Huang and Lu, 2013).

This study tests the influence of two different colour combinations (complementary colours *vs.* analogous colours), as opposed to single colours, on consumer expectations on calories, healthiness and purchase intention. According to Itten (2001), complementary colours are those opposite to each other on the colour wheel (e.g., orange and blue) whereas analogous colours are those next to each other on the colour wheel (e.g., green and blue). Hence, we chose to test these specific colour combinations: 1) orange and blue, for the complementary set; and 2) green and blue, for the analogous set.

According to Dong (2013), a red package leads to higher calorie perception than a blue one. Additionally, cool colours are perceived as less caloric and healthier (Carels *et al*., 2006). Hence, we expect that the contrast produced by complementary colours would also induce a higher calorie perception. We then predict that the package with one higher wavelength colour (i.e., orange) would be perceived as more caloric. Therefore, the following hypothesis is proposed:

H1. The orange and blue package of cookies (the complementary colours combination) is perceived as having more calories than the blue and green package.

Research suggests that packages using colours with a high wavelength hue are perceived to be less healthy than low wavelength hue (Huang and Lu, 2013). Moreover, Schuldt (2013) stated that there is an association between green and "healthy". He argues that this association is probably justified by the generic positive associations carried by green and its associations with nature. Blue is also associated with healthier products: most of the food products considered "light" are coloured with blue. Therefore, it is expected that packages using only one "healthy" colour, in comparison with packages using two "healthy" colours, would lead to a less healthy product perception. Accordingly, the following hypothesis is proposed:

H2. The orange and blue package of cookies (the complementary colours combination) is perceived as being less healthy than the blue and green package.

Although consumers are becoming more concerned with health issues, they are not expected to purchase packages perceived as healthier, especially when buying hedonic food products such as cookies. Consumers tend to buy packages that attract more their attention. Previous research indicates that high wavelength colours attract more attention than low wavelength colours. Therefore, it is expected that consumers would reveal a higher intention to purchase packages using high wavelength colours. Additionally, complementary colours, in comparison with analogous colours, tend to create a higher contrast and, consequently, a stronger visual engagement. Consequently, purchase intention is expected to be higher for packages using complementary colours. Hence, the last hypothesis is proposed:

H3. There is a higher intention to purchase the orange and blue package of cookies (the complementary colours combination) than the blue and green one.

EXPERIMENTAL

The present study used a quantitative approach and a quasi-experimental within-subjects design. An online survey was developed and shared using Facebook as the main platform. Participants were presented with two colour combinations: blue and orange *vs.* blue and green. The dependent variables are: calorie estimation, healthiness perception, and purchase intention. The two packages were designed by manipulating (via Photoshop) a regular package of digestive cookies. To avoid biases in responses (i.e., brand or category effects), we chose a brand that is not sold in the traditional supermarkets in Portugal and the pictures of the cookies were also removed from the original package. The brand logo and the wording of the package were edited and coloured in white to avoid interferences in the image reading. Figure 1 shows the two packages used for this study.

Figure 1: Packages orange and blue *vs.* green and blue.

The questionnaire encompassed six sections of questions. The first section aimed at gathering demographic data about participants, such as age, gender and occupation. The second section entailed a brief colour vision test for colour-blindness (Ishihara, 1972). This test was performed since colour-blind people are often not aware of their inability. The test consisted of eight coloured circles with numbers inside. The responses of the participants who failed two or more (out of eight) numbers were not considered for the study. The third section was developed to support the cover story (Koo and Suk, 2016). Therefore, participants were asked about the frequency of consumption and their preferred brands of cookies. In the fourth and fifth sections of the questionnaire, participants were confronted with two different packages. They were asked to rate healthiness and calorie perceptions (Huang and Lu, 2015) and to estimate the calorie content of the presented package compared to a traditional package of digestive cookies. Similar comparative judgements have been previously used by Schuldt (2013). Also, participants were asked to report their likelihood of purchasing the package shown (Dong, 2013). In the last section, the two packages were displayed in a random order and participants were asked to choose the one they would prefer to buy.

To measure which combination of colours is perceived as being healthier and less caloric, participants had to rate their perceptions regarding the two packages. A semantic differential rating scale consisting of six bipolar adjectival statements, separated by a 7-point scale was employed (McCroskey *et al.*, 1967). The relevant adjectives used in the research were healthy/unhealthy and high calorie/low calorie. Nevertheless, four statements were added as control variables (sweet/not sweet, pleasant/unpleasant, tasty/distasteful and satiating/not satiating). Participants also estimated the calorie content of the packaging comparing to a reference package, using a 7-point Likert-type scale, ranging from "1 - less calories" to "7 – more calories". Lastly, the statements for the variable purchase intention were adopted from Mullet and Karson (1985), ranging from "definitely will buy" to "definitely will not buy", using a 5-point Likert-type scale.

In total, 383 people responded to the survey. However, 39 answers were considered invalid due to missing responses or failure in the colour blindness test. Hence, the final sample included 344 participants (68.3% females; mean age 28 years old; age range from 12 to 70 years old). Regarding occupation, 53.5% of them were students, 40.4% were currently employed, 4.7% were unemployed and only 1.5% were retired.

RESULTS AND DISCUSSION

To measure the participants' calorie perception concerning each package, two items were analysed: the "high calorie/low calorie" item and the calorie estimation in comparison with the traditional package of digestive cookies. Regarding the first item, the blue and orange package was rated as the package containing more calories (M = 4.64; SD = 1.651). Accordingly, the blue and green package was perceived as having less calories (M = 3.65; SD = 1.398). A paired-sample t-test revealed that the blue and orange package is significantly different regarding perceived calories, when compared to the blue and green package, as $t(343) = 10.366$ and $p < .001$ ($p = .000$).

The analysis of the second item mentioned reinforced the previous findings. Therefore, the blue and orange package was perceived as containing more calories than a traditional package (M = 4.03; SD = 1.192) and the blue and green package was perceived as containing less calories (M = 3.25; SD = 1.178). A paired-sample t-test revealed that the blue and orange package differed significantly from the blue and green package in perceived calories, as $t(343) = 11.070$ and $p < .001$

(p = .000). Therefore, hypothesis 1 is confirmed.

To evaluate participants' perception concerning product healthiness, only the "healthy/unhealthy" item was analysed. The 7-point scale applied ranges from "1 – healthy" to "7 – unhealthy". Descriptive statistics showed that the blue and orange package was rated as being the less healthy (M = 4.01; SD = 1.617). Accordingly, the blue and green package was perceived as being the healthiest (M = 2.96; SD = 1.297). Again, the data were analysed using a paired-sample t-test. Supporting the initial expectations, the statistical test showed that the blue and orange package is significantly different in perceived healthiness when compared with the blue and green package, as $t(343) = 9.800$ and $p < .001$ (p = .000). Accordingly, hypothesis 2 is confirmed.

To analyse which package elicited higher intention to purchase, two dimensions were explored: first, the likelihood of purchasing each package; and second, the participants' preferred package. Regarding the first dimension mentioned, descriptive statistics revealed participants are, on average, more likely to buy the blue and orange package (M = 3.19; SD = .913) than the blue and green package (M = 3.08; SD = .938). According to the initial predictions, a paired-sample t-test showed that the probability of buying the blue and orange package is significantly different from the probability of buying the blue and green package, as $t(343) = 2.620$ and $p < .01$ (p = .009). Regarding the second dimension mentioned before, descriptive statistics revealed that, when participants had to choose only one of the two packages, they preferred the blue and orange package. To perform the appropriate t-test, a dummy variable was created: participants who preferred the blue and orange package were assigned with 0 and participants who preferred the blue and green package were assigned with 1. In this case, a one sample t-test was carried out. Again, the statistical test indicated that the preference for the blue and orange package is significantly different from the preference for the blue and green package, as $t(343) = 24.209$ and $p < .001$ (p = .000). Overall, hypothesis 3 is confirmed.

Our results confirmed the three formulated hypotheses. Results indicate that, when complementary colours are combined in a package, consumers perceive that package as being less healthy and having more calories. In contrast, when analogous colours are combined in a package, that package is perceived as having less calories and as being healthier. One explanation for this finding is that this analogous colour set includes cool colours (i.e., blue and green), which is associated to freshness and healthiness. However, it is plausible that high wavelength colours – such as orange – are perceived to be less healthy than low wavelength colours (Huang and Lu, 2013).

The findings of this study also suggest that consumers demonstrate a higher intention to purchasing packages using complementary colours rather than packages using analogous colours. This result might be explained by the fact that complementary colours attract more attention due to their inherent contrast (Itten, 2001), and that consumers possibly choose products that draw their attention easily, particularly when buying low involvement products. Our results partially contradict the findings of Huang and Lu (2013), which evidenced that there is a higher intention to purchase blue packaged products.

In line with the existing literature, the results of this study also indicate that there is an association between healthiness perception and calorie estimation. Consumers perceive healthy products as having a low calorie content and unhealthy products as having a high calorie content (Harper and Konrad, 2006). Therefore, the package rated as the healthiest was also classified as having less calories. Also, the observed results about consumers' purchase intention suggest that consumers are not so concerned about health issues, as they prefer to buy the package they rated as being the less healthy and the most caloric.

In accordance with Huang and Lu (2015), the observed results indicate that colour works as a visual marketing cue, so that key information could be communicated to consumers. Specifically, in the case managers wish that a product is perceived as a healthier (and low calorie) one, they should use a package with analogous colours – in particular, green and blue. Finally, managers are becoming increasingly concerned with healthy issues and are changing products' image. Therefore, brand positioning and repositioning strategies could benefit from the findings of this research.

As any research, this study entails some limitations which should be taken into account in future research. As participants were mainly Portuguese, this limits the external validity of this study, since previous research has shown that perceptions and meanings of colours might vary across cultures (Madden *et al*., 2000). Therefore, future research should examine potential cultural differences in colour and calories perceptions. Second, the demographic range that the selected sample encompasses might not achieve full representation of the population, since most of the participants were young adults. Third, though the packages designed were based on an existing package, the edition of the packages using Photoshop may have affected respondents' perceptions, since there are many features impacting these perceptions, such as font, imagery, shape and size. Accordingly, further research should use a larger range of colours to confirm the validity of the observed results. Future research could also adopt a qualitative approach with the purpose of gathering directly participants' opinions, perceptions and considerations. Fourth, future large-scale researches should follow a between-subject design, to avoid having the participants answer the same questions twice. This way, participants would be assigned into different colour conditions, which would result in less contamination by extraneous factors (i.e., common method bias). Fifth, this study is limited in its external validity, since it explored only one product category. Further research could analyse other low involvement products. Finally, another avenue for future studies would be to examine how other packaging features might affect calorie perceptions and perceived healthiness. For instance, the material of the package might play a role in consumer's perceptions.

CONCLUSION

The design of a product influences consumers' perceptions and, consequently, their choice. The present work examined how different combinations of colours (complementary *vs.* analogous) influence consumers' perceptions on calories and healthiness and their intention to purchase. Therefore, product managers should consider the associations and expectations that consumers have regarding colours, so that the brand and product qualities are successfully and effectively communicated. This research sheds light into the colour and consumer behaviour literature.

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Chromophobia in contemporary artistic practices

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ABSTRACT
More than interdisciplinary, colour emerges as a powerful tool with its own and autonomous value that does not allow itself to be disciplined, although centuries of cultural history tried to attribute powerful symbolic meanings to this expressive force. The investigation I have been developing as a visual artist that privileges colour as a fundamental composition element, questions what happened to colour after the theories that have tried to systemize it and the role of colour in contemporary art: is chromophobia, a concept advanced by David Batchelor, contaminating contemporary practices, as well as the critical mass and agents that influence the current art world? It is worth reflecting on the possibility that chromophobia influences the understanding of the place of colour in contemporary art and, on the other hand, how it is interleaved with the apology of colour, as it has been through several moments of history, often surprisingly.

Keywords: *Colour, prejudice, chromophobia, contemporary art, painting*

INTRODUCTION
Colour, a visual and expressive element with a tremendous transformative potential, simultaneously strange and seductive, unverifiable and unlimited, has meanings that are anything but universal or transversal to distinct areas of knowledge. In the field of visual arts, specifically, perhaps the possible knowledge and understanding of colour resides in experience and in the act of doing things, experimenting and transforming.

Nowadays, it is worth questioning what happened to colour after the theories that have tried to systemize it, for these have yet to provide an unequivocal and irrefutable knowledge, generating instead further possibilities of disruption and reinvention. It was Ann Temkin that raised the question in 2008: “What defines colour *after* colour theory?” (Temkin, 2008: p. 8). Temkin was the curator of *Colour Chart: Reinventing Colour, 1950 to Today*, which was held at MoMA in 2008 and brought together the work of forty-four artists who, at some point in their careers, privileged colour. The theme of the exhibition was the colour charts, in which colour is assumed as a subject and an experience dissociated from an object, a function or a significance. This approach contradicted the enduring convictions regarding the spiritual and subjective character of colour, which lost ground throughout the twentieth century. Through a brief historical introduction, it is possible to notice that there were significant changes in the approach to colour, by artists and theorists, from the 1960s: colour gained autonomy and became used as it is, regardless of its traditional symbolic, expressive or decorative character, gaining strength in unexpected contexts, often assumed as a concept or the subject itself. It seems that, currently and in the field of visual arts, colour is more associated to a fluid randomness field, to chance and intuition, than to its scientific and systematic aspect of an orderly management of principles and rules. So, today, artists themselves may be writing a colour history through the artistic objects they add to the world, talking about colour in and through practice, even though this more or less privileged use of colour may not be recognized, valued or systematized. In fact, that presence and relevance of colour in contemporary art seems to lack a critical discourse that accompanies and emphasizes it. Furthermore, in some platforms of art diffusion, such as art galleries and press articles, works of art where colour prevails seem to be more scarce. As an artist who works with colour and thinks about it in a recidivist way, I can assume that my work does not always seem to fit into the program and options of certain galleries, to give an example. It seems that colour is connected to beauty and the pleasure of looking and beautiful artworks that stimulate our senses are not as compatible with a conceptual project, for instance.

The artistic practice that I have been developing uses colour as a central and autonomous element that composes the artwork through its relations and tensions. I intend to appeal to our desire to inhabit and experiment spaces manipulated by colour, a fundamental composition element that interacts with the idea of the house, a primordial thematic and conceptual element in my practice. So, in my body of work painting converses with architecture through a mutual questioning and hybridization and, generally, the pictorial dimension prevails, as a result of colour being privileged as a powerful expressive and visual element.

Figure 1: Ana Pais Oliveira, Ar livre #2, Acrylic on canvas and maritime plywood, 200x290cm, 2017.

Working with colour in the studio also encouraged me to develop a doctoral research which aimed to bring to light cases where colour, remaining undisciplinable and untameable, takes on a leading role in that annulment of boundaries between painting and architecture. At the end of this research I could notice the incredible strength of colour in many artistic and architectural contemporary expressions and works, despite the acknowledgement of a certain chromophobia that contaminates contemporary artistic practices and their dissemination platforms. This paper intends to question if that chromophobia, a concept advanced by David Batchelor in 2008, influences the role of colour in contemporary artistic practices and to what extent colour is relevant in the practice of contemporary artists, as a theme, concept, medium, matter, central element of artistic practice or the basis of the creative process.

Figure 2: Ana Pais Oliveira, Heavy drawing #36, #26 and #33, Mixed media on cardboard, 70x50cm each, 2017.

CHROMOPHOBIA AND THE ABSENCE OF COLOUR

Whiteness always returns.[1]

In Cromophobia (2000), David Batchelor argues that colour has been the object of extreme prejudice in Western culture, systematically marginalized and diminished, since antiquity, by generations of philosophers, artists, art historians and theorists. Batchelor justifies this prejudice with the fear of actually being contaminated or corrupted by something that is unknown or seems unknowable, considering two essential values of this chromophobia: the understanding of colour as part of an external body, usually the feminine, the oriental, the primitive, the infant or the pathological; or the relegation of colour to the field of superficial, supplementary, unnecessary or cosmetic, a secondary quality of experience. So, colour would be dangerous, trivial or both. For Batchelor, evidence of this chromophobia in the West can be found already in Aristotle, for whom the repository of thought in art resided on the line. The rest would be ornament. Moving forward to today, the author argues that it remains the often-unspoken belief that seriousness in art and culture is a black and white issue (Batchelor, 2008: 30). This positioning is found in the discourse of several artists, architects, historians and art critics, among others, who put colour as an element that could eventually harm the success of the artwork and distort this seriousness and acceptance: “Colour was supposed to be kitsch, bad taste. Serious art was black-and-white.” (Dibbets, 2006: 164).

Briony Fer (2008) adds that Theodor Adorno espoused the ideal of black as one of the deepest impulses of contemporary art, noting that there is something almost childlike in the pleasures offered by colour. But, regarding this position, Briony Fer states: “If colour had come to seem like art’s greatest irrelevance, then it also proved a surprisingly effective means to save it from itself.” (Fer, 2008: 29). Fer adds that the renunciation of colour has reached its highest point at the moment of Conceptualism, and the remnants of this resignation are still felt, being interesting to

[1] BATCHELOR, David (2000). *Cromophobia*. London: Reaktion Books Ltd., p. 19.

note that the chromatic innovations that emerged, still connected with conceptual art, were largely ignored. For this reason, an artist like Donald Judd was slow to be recognized as one of the great colourists of the twentieth century, as Donald Judd's own 1963 statement that the most interesting thing in Warhol is colour, took a long time to be accepted and registered: "Far from being immediate, the historical effects of colour seem on the contrary to be subject to lapses in time and, more often than not, delayed." (Fer, 2008: 30).

Colour is definitely not the first element we remember when we think of minimalism or conceptual art, and it surprises us that some of these artists take on the role of colourists. It seems like a provocation on their part, but we can look closely to realize colour is there. If colour is there, what makes us not recognize it?

What Batchelor argues is that something significantly important happened to colour in the art in the 1960s, identifying with the emergence of pop art and minimalism and, briefly, Frank Stella's well-known statement: "To keep the paint as good as it was in the can". One of the purposes of Batchelor's publication *Colour - Documents of Contemporary Art* (2008), is to save the colour discourse of its common and intuitive association with modernism and formalism, suggesting that it has a much more complex relationship with art and with modernity. And to do this, it is enough to begin by recognizing how, while some critics have not looked at the presence of colour as a valuable subject, many contemporary artists have reacted to this prejudice by incorporating practical and theoretical concerns with colour in installation, photograph or video or using new combinations of unusual materials and colours in the traditional mediums of art.

Meanwhile, colour charts have disassociated the colour of its recognized decorative and ornamental side, ending up dissolving the prejudice towards colour through a new approach. A colour chart is only a list where each colour is independent of the other and, as we have been analyzing, this is a new positioning that decomposes the interpretation and manipulation of colour, and, through this action, can override the prejudice recognized by Batchelor. That is why the exhibition curated by Ann Temkin in 2008 at the MoMa brought to light significance changes. The acknowledgement of colour as a matter-of-fact element, common and accessible, rather than a vehicle of spiritual or emotional content, represented a major artistic shift that took place during the middle of the twentieth century. Artists themselves started rejecting the artistic traditional pedagogy about the right colour relationships and, instead, adopted aesthetical approaches that relied in ready-made sources and arbitrary systems, using colour bought off the shelf or assigned by chance, loosing the idea of the traditional colour harmonies. So, with no hierarchies, colour is assumed as a theme, a concept, a source and raw material, simultaneously. Colour is colour and doesn't have to be associated to an object, a landscape or an excerpt of architecture. Artists like Donald Judd and Gerhard Richter sought an approach to colour through the intellect and not through an emotional or sentimental level. With his colour charts, Richter concentrated on accident, indifference, and the pleasure in looking and broke with all forms of expressive and symbolic statement associated to colour. Other artists like Jasper Johns, Ellsworth Kelly, Kenneth Noland, Al Held, Sol Le Witt and Frank Stella worked with colour charts, dissociating colour from any traditional mean or strategy.

In another case, the work of Ian Davenport, colour is used as a way of seducing. Sheryl Garratt (2014) writes that she feels nervous about writing about this type of art, which apparently is not about anything, and it is difficult to find the words. However, she feels good looking to Davenport's paintings. To this question the artist replies that we do not have to be intellectual in the language of art to enjoy his work. Garratt says that Davenport uses the words *juicy* and *seductive* to describe his latest experiments with colour: “Sometimes people get too worried that they’re missing the point, thinking there should be some sophisticated thing behind all art. But just your response to the colour can be enough” (Davenport in Garratt, 2014). Davenport's work assumes colour as a subject. It is also about its materiality and physicality, about ink, about how it behaves on a surface, how it flows and merges, its texture and weight, its brightness, how accidents cause visual and formal episodes, in an extremely physical process. This is beauty, pleasure, experimentation and sensation and there should not be a prejudice regarding this intuitive and expressive way of working with colour. Sherrie Levine herself said: "I think of myself as a colourist, and people laugh when I tell them that, but it's true." Perhaps the artist's recognition as a colourist, or centred on the sensory issues of the work of art, was set aside because of the focus on the rigorous conceptualism of her project. Here we have the feeling that there is a prejudice that precludes the association between an assumedly conceptual art and the profuse and expansive use of colour. Sol LeWitt, in whose work colour is central, stated that he did not care that his work was considered beautiful, making dismiss what appears to be a part of the reason for the chromophobia: the prejudice associated with the seductive character of colour and the experimentalist pleasure of its manipulation. And if colour is sometimes associated with something accessory, merely visual, or deviating from the real function of the work of art, it intrigues us that it has assumed an important importance in the work of artists such as Sol LeWitt, Dan Graham, or Sherrie Levine. In the case of Sol LeWitt, there is, in fact, this antithesis between his conceptual positioning and the fascination he had for colour. However, there may simply be no contradiction at all. There may be the evidence of a new paradigm in the approach to colour, which has ceased to be seen as an emotional, subjective, spiritual vehicle and associated with a long-standing theoretical tradition, being used as it is: colour no more than herself. Therefore, we could balance this association of colour to a useless, decorative, excessive or eccentric field with the claim that colour is today used more boldly and free than ever before. In addition, it is possible to recognize that colour has had a much more significant presence at some moments in history, notably in contemporary examples, than what is documented or recognized. It is in this context that the importance of the concept, recognized as essential in the course of certain artists, has sometimes been interspersed or intercepted by moments of visual pleasure that derive from a profuse and privileged use of colour.

FINAL CONSIDERATIONS

Today, as a painter who works with colour in a recidivist and assumed way, and who deals with the fact that the works also *become beautiful*, I recognize the sensation of the effects of chromophobia, in certain contexts, agents and platforms of dissemination of contemporary art . It is obviously not something generalized, but it exists. However, almost all artists have to make chromatic choices to shape their ideas and deal with the realization that there are no rules, only possibilities. The difference then lies in the way the artist relates to his own colour manipulation strategies and emphasizes them as a significant part of his creative process. At this point, I appropriate David Batchelor's words for an important conclusion: "To make work that has colour is very different from making that work about colour." (Batchelor, 2013: 81). Thus, the widespread prejudice of colour seems to conceal its real importance, often not assumed or recognized at the time when it is being widely used in artistic practice, by the artists themselves and by those who write about their work. However, Briony Fer’s statement makes sense: colour, having been considered as the greatest irrelevance of art and having its rejection manifested itself in different ways to this day, was the first to react and save herself, moving towards autonomy and experience.

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The diegetic colour in the Brazilian miniseries *Suburbia*

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ABSTRACT
This paper presents a chromatic analysis of the Brazilian miniseries *Suburbia* (Globo Television, 2012), considering the conceptual relation between narrative, staging and art direction, and its visual projections in the miniseries images. The research proposes the "diegetic colour" concept by the study of the audiovisual art direction processes, considering its dialogue with the photography direction. The art direction is responsible for the material design of diegetic spaces and characters and it is one of main aesthetic base of the film and television image visual aspect. The colour should be considered the most important layer of creation in the art direction, connecting all elements of the scene.

Keywords: *Colour, art direction, audiovisual, television, Luiz Fernando Carvalho.*

INTRODUCTION

The "diegetic colour" is a concept resulting by the study of the colour syntax in the audiovisual image. According to Aumont (1993), the diegesis is an imaginary construction, a fictitious world with its own laws more or less similar to the laws of the natural world. The audiovisual diegesis is the characters' universe: history, spaces, time perception, materiality, sounds. Thus, to think about "diegetic colour" we do not have to think only about the film colour palette itself, but its expression at the film universe by the colour scene components like scenarios and scenes objects, characters, costumes and makeup, considering the material shapes. Yet how this set is registered under a specific light design and the post production chromatic process.

Therefore, the "diegetic colour" should be understood as a perceptive frame formed for layers resulting by the interferences on the hue material bases of scenes, that is saturated or attenuated for to rear specific meanings. The movie credits colour, subtitles and opening sequences by digital computing are considered here like extra diegetic colours because does not compose the characters universe.

In this sense, the colour is a essential visual element in art direction processes. In the audiovisual narrative, the art direction is one of the creative areas that builds cinematographic and TV visual design. It is responsible for transcription of textual guidelines to the scenic materiality. It works with the photography direction to define the visual language of the movie or serie - the atmosphere, ambience, textures and colours - that is spatially designed in the images, corroborate the construction of credible diegetic universes and the visual expression of characters that occupate and interage in these spaces.

In the miniseries *Suburbia*, the colour is the main visual element and it is essential to narrative development. The colour application format is expressive to a recurrent aesthetic on the contemporary television production that to objectify to capture the televiewer attention by the chromatism effects. In *Suburbia*, however, it is possible to verify a strong visual concept by the colour. This paper presents an analysis on the "diegetic colour" in *Suburbia*, considering the conceptual relation between narrative, staging and art direction, and its visual projections in the miniseries images.

EXPERIMENTAL

Suburbia (2012) was directed by Luiz Fernando Carvalho and wrote by Carvalho and Paulo Lins (the *Cidade de Deus* book's author). The miniseries has eight chapters that presents a Rio de Janeiro's suburbs: the black and poor population's life, the violence, the social behaviours and cultural manifestations. In the *Suburbia*'s visual narrative is presented all the colours of Brazilian black culture: dances, parties, garments, religions and buildings. The chromatic creation is one of the responsibles for the visual narrative expressivity, resulted by a competent material and visual research.

Figure 1: Suburbia's frame by Globo Television.

The miniseries presents Conceição's history, a black young women that dreams to be a popular dancer, describing her trajectory since she was a charcoal slave girl in Brazil's countryside until her difficulties when she arrived in Rio de Janeiro's city and went to live in Madureira, Rio de Janeiro's suburb. Conceição confronts many adversities in her life: the brother's death, illiteracy, prison and sexual violence. The title “suburbia” refers to the Conceição's codename when she worked as a Brazilian funk dancer. On the other hand, she feels really fulfilled when becomes the samba school queen.

The miniseries' visual creative process had as references the brazilian black culture, musicality and religiosity. The suburb was represented like a contrastant space. On the one hand, bucolic and kind, and on the other very poor and violent. The violence of drug traffic and Brazilian funk's parties are approached by narrative. The visual project proceeds a realist stage proposed by the direction, but is full of an intense lirism.

The *Suburbia*'s “diegetic colour” express the protagonist's emotions. The colour palette is composed predominantly of blue, red, yellow and green, that were applied in saturation or attenuation mainly “in ascending” (GUIMARÃES, 2000). This composition interacts in most of scenes with a diffuse white light or determines the artificial lights chromatism. This study considers the image of “Nossa Senhora da Conceição Aparecida”, the Brazil's saint patroness, as the main conceptual visual reference to the colour palette.

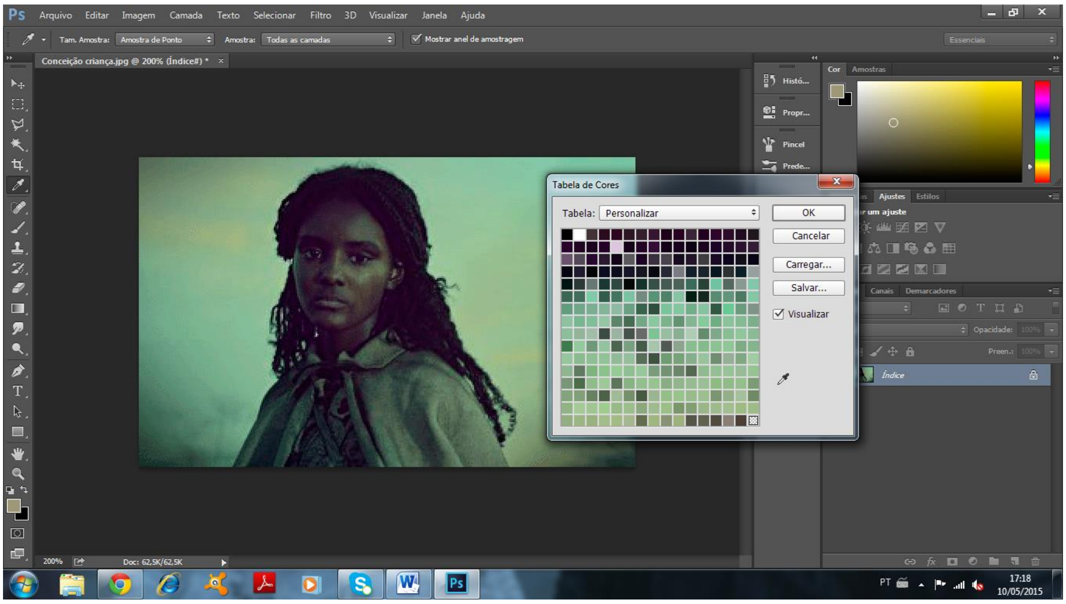

Figure 2: Colour palette by prologue narrative. Photoshop Interface and frame by Globo Television.

It is possible to verify the images colour symbolism. For example, in the prologue, when Conceição lives as a charcoal slave girl, there is a predominance of blue to represent an atmosphere of dream and timeless. When the protagonist arrives in Rio de Janeiro's city the colour palette transformation is notorious. The images become colourful, which reflects the Conceição's enchantment and surprising. When she went to live at the suburb, the hues are attenuated, becoming more clear. This chromatic aspect can be associated to suburb bucolic representation. However, when Conceição is crowned as the samba school queen, the colours become saturated, reflecting in the Conceição's satisfaction.

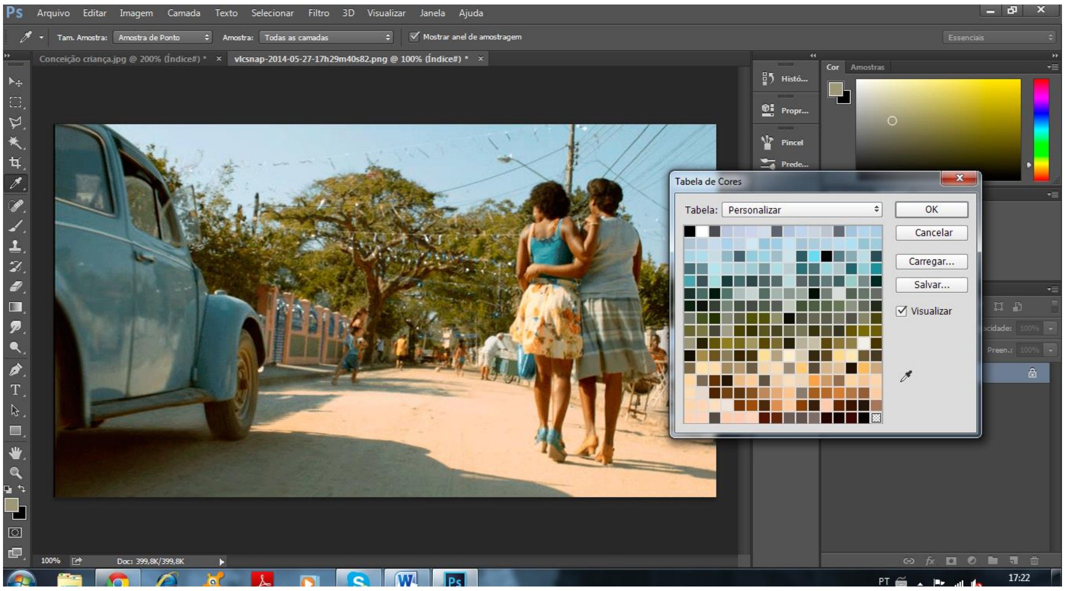

Figure 3: Suburb's colour palette. Photoshop Interface and frame by Globo Television.

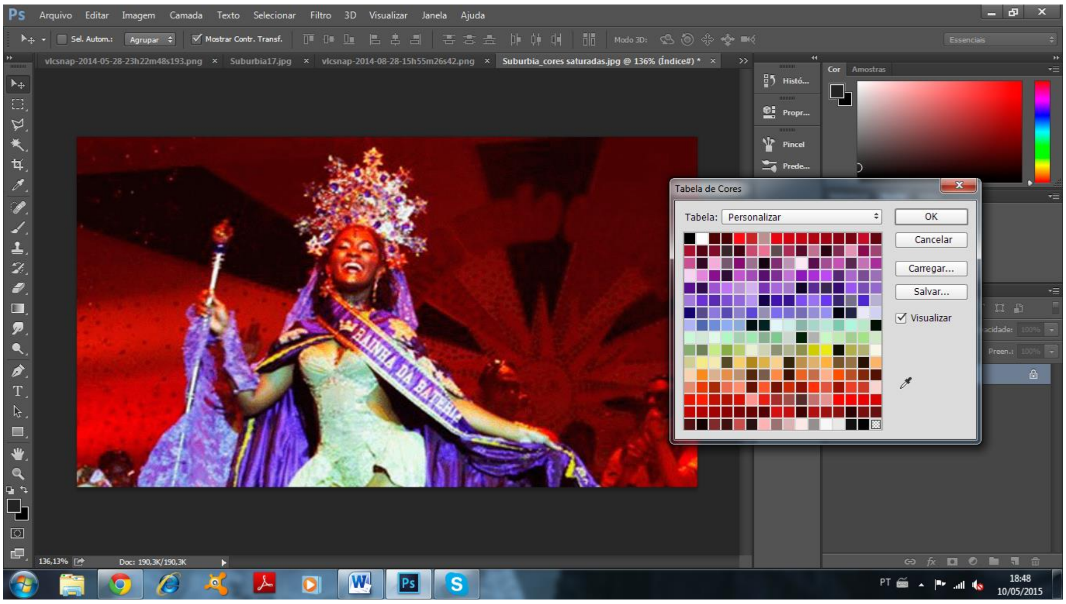

Figure 4: Saturated colours in *Suburbia*. Frame by Globo Television.

RESULTS AND DISCUSSION

The *Suburbia*'s "diegetic colour" is resulted by an art direction's design focused on a representation of the Brazilian black population suburbs. The colour symbolism express these scenes drama concept and the black protagonist's emotions. Therefore, *Suburbia*'s chromatism presents some of the visual identity elements of the Afro Brazilian culture. This chromatism can be found in all material scene elements such as costumes, scenarios and make up. In the *Figure 2*, for example, it is possible to observe how the characters' costumes colours visually dialogues to the others scenes elements in order to build the final image visuality and its narratives and symbolisms. In the *Figure 3*, the costume design is scene colour protagonist and its saturated expression reflects the coloured scenes lights.

CONCLUSION

The “diegetic colour” in the movie and television series is one the most important visual elements. This study considers that the audiovisual colour construction must be related to a research on the production's diegetic universe and not to pre-conceived colour symbologies. The “diegetic colour” reflects the scenes atmosphere and it is related to narrative concepts. The art direction expresses through visual narrative the possibilities of using colours from a specific cultural background.

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colour & human comfort

Colour in Children's Furniture – emotion and sustainability

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ABSTRACT

In a product design research about children's furniture and its adaptation to the child and sustainability, the aim is to search for solutions, which can follow child's growth. Namely, through a project of a high chair with an age target from 6 months up to 7 years of age, capable of contributing to sustainable development with a longer product life cycle. Given the concept of affective sustainability to prevent waste, enabling a stronger bond with a product and colour possibly being an important element in the child's emotional response and product attachment, this study searched for a relationship between colour and sustainability. Dealing with variables such as gender, age, education and cultural background and the concepts of emotional and pleasurable design, the results of this literary review based study made it possible to narrow the chromatic choices to a limited range of colours, which would be optional in this design project.

Keywords: *Children's Furniture, Product Design, Colour in Design, Emotion, Sustainability*

INTRODUCTION

In the context of a product design research about children's furniture and its adaptation to the child and sustainability, the aim is to find solutions, which can follow child's growth. Namely, through a design project of a high chair, with an age target from 6 months up to 7 years of age, capable of contributing to a sustainable development, with a longer product life cycle. A study about colour, emotional response and product attachment seemed necessary in this research project.

Although the focus lays many times in form and function and how the object physically adapts to the user, chromatic properties may be relevant to a psychological appropriation and a lasting bond to the object in question. When the main target is a child, who has a sensitive and prone to change nature, the subject is more difficult to approach, when it comes to colour perception. But parents, as indirect users and consumers/buyers have also, to be taken under account.

Given the concept of affective sustainability to prevent waste, enabling a stronger bond with a product, colour preference may be an important element in the child's emotional response and product attachment. Dealing with variables such as gender, age, education and cultural background and the concepts of emotional and pleasurable design, this literary review based study searched for a relationship between colour and sustainability.

The choices for the high chairs' structural material were beech (a hardwood) and pine (a softwood). According to recent studies by the author, it was concluded to be a primary option, to leave at sight the natural colouring of wooden materials. Therefore, this study seeks for chromatic and/or achromatic secondary options for the high chairs' design project.

AFFECTIVE SUSTAINABILITY

The designer's professional social responsibility is generally recognized in nowadays society (Borjesson, 2006), being responsible design one important way to deal with a wasteful society (Papanek, 1995). Affective sustainability can contribute in a fairly wide sense to reducing the desire for new objects, which might cause a slowdown in the economic system (Borjesson, 2006). However, instead of having a large number of versions for the same needs, we might experience and get attached to products more suitable for us, performing better with less, stimulating a responsible, ethical and conscious consumerism.

When emotional attachment is seen as a precondition for a products' sustainability and designing pleasurable products may create a bond between user and product (Borjesson, 2008), searching for features, which may provide bigger emotional attachment to a certain object, is important in an optimized design project (Jordan, 1998). Besides sensual experience, context (social and cultural backgrounds, both being prone to change) also has its influence on pleasure. Then, durable attachment will be difficult to achieve (Jordan, 2000). But as far as meaning goes, if visual and verbal communications are combined, cultural differences can disappear (Pöppel, 2007). Theodor Lipps' (1851-1914) early theories on empathy, linked emotional bonding with an object with a projection of oneself in it, being a non-cognitive process, this aesthetic experience is an "objectified self-enjoyment" (Lipps, 2012, p. 127). By possessing material goods, the subject is enabled to "incorporate" the meanings that are signified to them by a certain object (Fromm, 2005, p. 40). As Chapman stated, "waste" is the result of broken (emotional) relationships (Chapman, 2005). Emotional bonding with objects, through processes of identification and pleasure in use, may lead to a more suitable and sustainable material environment.

In a study about creation of emotional comfort through modern design, colour is mentioned, along with form and sound, stating emotional colouring affects all geometric objects, causing persistent feelings, which can be described and systematized (Kukhta and Pelevin, 2015). A particular colour or sound can cause us pleasure and displeasure emotions in the same way as other elements as line, plane and volume can. Having colour much importance in the perception of the object by the user, it may be relevant to product attachment and emotional bonding, contributing therefore, to an affective sustainability in product design.

COLOUR AND EMOTION

Colour is an essential component of nature, which will complete humans' interaction with the surroundings (Mohebbi, 2014). Children react to their surrounding environment and try to communicate with it and because of the energy within bright colours, they naturally tend to like lighter colours more than darker ones, possibly associating darkness with sadness.

Johannes Itten, strongly associated with Bauhaus' first period (Droste, 2006), suffered great influence by Goethe's colour theory (Goethe, 1982), with special interest in contrasts, for a study of Colour Esthetics (Itten, 1970, p. 13). And such study influenced many designers and artists. Previous studies (Salvador, 2014), explored the use of colour contrasts and its potentiality of emotionally capture adults and specifically children, also through Itten's influences, in examples of illustrated children's books of african tales by Danuta Wojciechowska. Blue in all of its shades and yellow deriving darker forms until reddish shades, were highly present in these illustrations. A great amount of colour saturation composed the intense and attractive images.

According to a study about colour in marketing (Sliburyte, Skeryte, 2014), the consumers' colour perception depended on the demographical factors, although with exceptions, because people of different age, gender and education perceived colour differently. Some research studies are concerned with exploring the emotional meanings and effects of colour, examining emotional associations to colours and others focus on colour preferences according to gender or even to educational backgrounds (Hanafy and Sanad, 2015). Eysenck, through his research (using ten Ostwald coloured papers as stimuli, on equal number of female and male university students) acknowledged the existence of a general order of preference for colours (Eysenck, 1941). Being blue, the most preferred colour followed by red, green, violet, orange and yellow.

In a study on gender-based colour preferences in children, through Luscher's tests (Mohebbi, 2014), the psychological characteristics of some of the colours tested, described blue as total peace, relaxation and harmony, loyalty and confidence; red as intensity, success, love, leadership, artistic and creative expression; green as self-consciousness, endurance and perseverance; yellow as cheerful and expansive, with adventure and concern for others; violet as mystical, erotic, intuitive and religious. It was concluded that only the change in children's preference in yellow colour with their age is noticeable and gender-based colour difference is meaningful for blue, green, pink, and black.

Ortiz Hernandez stated that the colours preferred by adults were blue, followed by red and green, whilst white, yellow and black were less preferred (Ortiz Hernandez, 1992). The results obtained in a study (Prado-León, 2015) specifically about the colour preferences in product design of household appliances, coincide with the chromatic results but not with the achromatic ones, given that white and black were much preferred when applied to this type of objects, which has a strong technological component. Despite cultural background differences, blue is also one of the favourite colours in many Asian countries, but white is also very much preferred (Schatz and Bowers, 2005).

Some studies also have reported differences by gender in adults, determining that the most attractive colour for women is red, and for men, it is blue and Ellis and Ficcek stated that men prefer blue and women' preferences are between blue and green (Ellis and Ficcek, 2001).

Many factors are implied in pleasurable design, but colour has been reported as one of the primary aspects, which attract users, generating relevant psychological effects (Leichtling, 2002). The results of these studies, can therefore contribute to a sustainably emotional design for users.

CONCLUSION

Colour seems relevant in product attachment, being an important key in product perception and identification with a strong emotional response and therefore may lead to an affective sustainability in product design.

This study contributed to narrow the chromatic choices for this design project, to a limited range of colours: three chromatic options – blue, red and green, along with two achromatic options - white and black (Fig. 1).

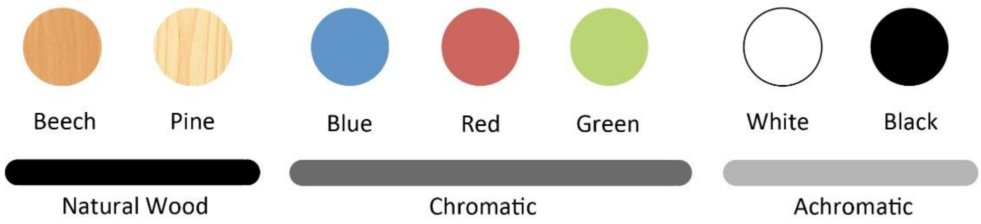

Figure 1: Possibilities of chromatic and achromatic options for the high chair's design project, along with the materials' natural colouring, digital illustration: Cristina Salvador, Portugal.

Blue seems to be perceived as calming and peaceful, red as intense and powerful and green as perseverant and balanced, whilst black and white seem to be associated with technology and efficiency. These were mentioned in most of the reviewed studies as chromatic and achromatic preferences, regarding several variables. Being the natural colouring of wooden materials the primary option, blue, red, green, white and black, partially or overall versions would be alternative or secondary options for the high chair' design project.

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A Study on Lighting Control Strategies Combining Daylight with White LEDs in Museums

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ABSTRACT

Daylight has high colour rendering and brings natural appearances of paintings. However, those appearances are not stable because the intensity and colour temperature of daylight always varies depending on the time and weather. There is a possibility that white LEDs that have an advantage in the easiness of controlling light intensity and colour while keeping high colour rendering could be used with daylight in a new way. This study aims to find out the appropriate lighting control strategies using both daylight and LEDs, which bring preferable lighting environment in museums. We have conducted painting assessment experiments in an experimental room using both purple-phosphor white LEDs as an alternative to daylight and LED spotlights. Results show that lighting conditions under which illuminance on the paintings was kept constant at around 200lx, even with the fluctuation of daylight LEDs, was generally highly evaluated in oil paintings for the appearance.

Keywords: *museum lighting, daylight, white LEDs, fluctuation, control strategies*

INTRODUCTION

Daylight has been used as one of the major museum lightings from the past. It has high colour rendering and brings natural appearances of paintings. However, those appearances are not stable because the intensity and colour temperature of daylight always changes depending on the time and weather. Recently white LEDs have been widespread in museums, and they have an advantage in the easiness of controlling light intensity and colour while keeping high colour rendering. There is a possibility that white LEDs could be used with daylight in a new way, where the daylight fluctuation will be taken full advantage of for an appreciation of paintings. The purpose of this study is to find out the appropriate lighting control strategies using both daylight and LEDs, which bring preferable lighting environment in museums.

EXPERIMENT METHODS

We conducted the experiment in which subjects evaluated the appearance of oil paintings and the preference for the fluctuation of lighting in experimental space. Phosphor-based white LEDs stimulated by purple LEDs was used for ambient lighting as an alternative to daylight (referred to as “daylight LEDs” in this paper), and LED spotlights were also used for illuminating paintings.

The experimental room as shown in Figure1 was 3000mm in width, 3000mm in depth and 2400mm in height. Buffering space for daylight LEDs was made in the location of 1900mm in height behind the subject. Lightness of the ceiling, the walls and the floor were N9.5 (White).

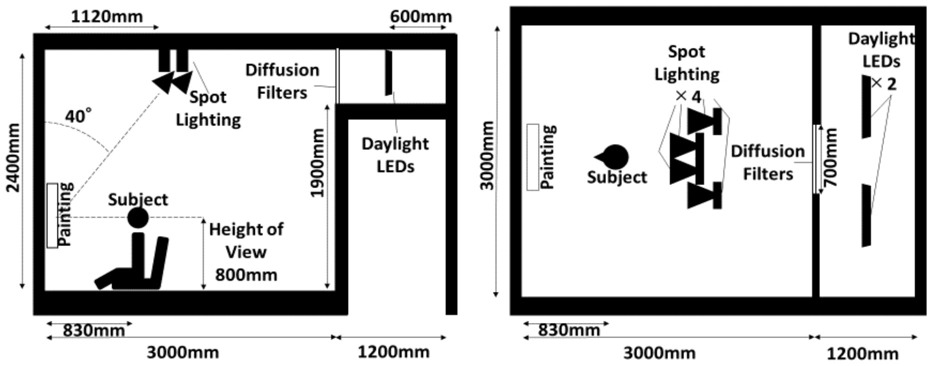

Figure 1: Section (left), Plan (right) of the experimental room.

Three oil paintings as shown in Figure2 were used in this experiment. The size was 530mm wide × 455mm height. Painting A with relatively low reflectance was “Red Mt.Fuji” drawn by Yasushi Nakao, Painting B was a replica of “Madonna of the Meadow” drawn by Giovanni Bellini, and Painting C is “Lake Como” drawn by Tadashi Orita.

Figure 2: Painting A (left), Painting B (center), Painting C (right).

Daylight LEDs (CCTs were 2700K and 6700K, Ra > 94) were installed in the high-sidelight position. It was verified in the previous experiment that subjects could not distinguish these LEDs from actual daylight. To reproduce natural daylight in the evening, the CCT of daylight LEDs was gradually changed from 6500K to 3000K, keeping duv <± 0.02, and its illuminance on the painting was changed from 150lx to 70lx, taking 22 minutes.

LED spotlights were phosphor-based white LEDs stimulated by purple LED, and their CCTs were 3000K, 4000K, 5000K (with a blue filter on the 4000K LEDs) and 9000K (with a blue filter on the 4700K LED). Ra values of all the LEDs exceeded 94. By mixing the light of 2 types of LEDs above, the intensity and CCT was changed.

13 lighting conditions were prepared as shown in Table1. Lighting condition: m was a standard condition and its intensity and CCT was kept constant. The lighting conditions were presented in random order for each participant.

<table>
<tr><th rowspan="2" colspan="2">Condition</th><th>Daylight</th><th colspan="2">Spotlight</th><th colspan="2">Daylight & Spotlight</th></tr>
<tr><th>Illuminance /CCT</th><th>Illuminance</th><th>CCT</th><th>Illuminance</th><th>CCT</th></tr>
<tr><td>a</td><td></td><td rowspan="12">Fluctuation 150lx~70lx 6500K~3000K</td><td rowspan="5">50lx</td><td>3000K</td><td rowspan="5">Fluctuation 200lx~120lx</td><td rowspan="10">Fluctuation</td></tr>
<tr><td>b</td><td></td><td>4000K</td></tr>
<tr><td>c</td><td></td><td>5000K</td></tr>
<tr><td>d</td><td></td><td>6500K</td></tr>
<tr><td>e</td><td></td><td>Fluctuation 6500K~3000K</td></tr>
<tr><td>f</td><td></td><td rowspan="5">Fluctuation 50lx~120lx</td><td>3000K</td><td rowspan="5">200lx</td></tr>
<tr><td>g</td><td></td><td>4000K</td></tr>
<tr><td>h</td><td></td><td>5000K</td></tr>
<tr><td>i</td><td></td><td>6500K</td></tr>
<tr><td>j</td><td></td><td>Fluctuation 6500K~3000K</td></tr>
<tr><td>k</td><td></td><td>Fluctuation 80lx~160lx</td><td rowspan="2">Fluctuation 3000K~9000K</td><td>230lx</td><td rowspan="2">5000K</td></tr>
<tr><td>l</td><td></td><td>80lx</td><td>Fluctuation 230lx~150lx</td></tr>
<tr><td>m</td><td></td><td>150lx,6500K</td><td>50lx</td><td>6500K</td><td>200lx</td><td>6500K</td></tr>
</table>

Table 1: The lighting conditions

19 students aged 21-28 without vision problems volunteered to participate this experiment. They evaluated the appearances of paintings three times, the 1st evaluation was done just after starting the lighting condition, the 2nd evaluation was done at 9.5 minutes after the start, and the 3rd evaluation was done at 19 minutes after the start. The 2nd and 3rd evaluation included questionnaires on lighting fluctuation as well. Subjects evaluated the appearance of the painting with 9-point bipolar scales, such as "-4: Not preferable" to "4: Preferable". As to lighting fluctuation, subjects evaluated at first whether or not they perceived the change, and then those who noticed the change evaluated the preference of fluctuation.

RESULTS

As to the percentages of the subjects who noticed the fluctuation, there were statistically significant differences between the standard condition and lots of other lighting conditions in the 3rd evaluation. Therefore, analyses below were done on the preference of fluctuation and the appearance of paintings only using the 3rd evaluation.

Figure 4 shows the preference of the fluctuation. There were no significant differences among lighting conditions. In Painting A, 2 types of lighting conditions as follows had a tendency to be highly evaluated: 1) illuminance on the paintings was kept constant at 200lx and CCT on the paintings was changed to 3000K (condition f, J), 2) illuminance on the paintings was lowered to 120lx and CCT on the paintings was gradually changed to 4000K (condition c, d). As to Painting B and C, lighting conditions that illuminance on the paintings was kept constant at around 200lx were highly evaluated.

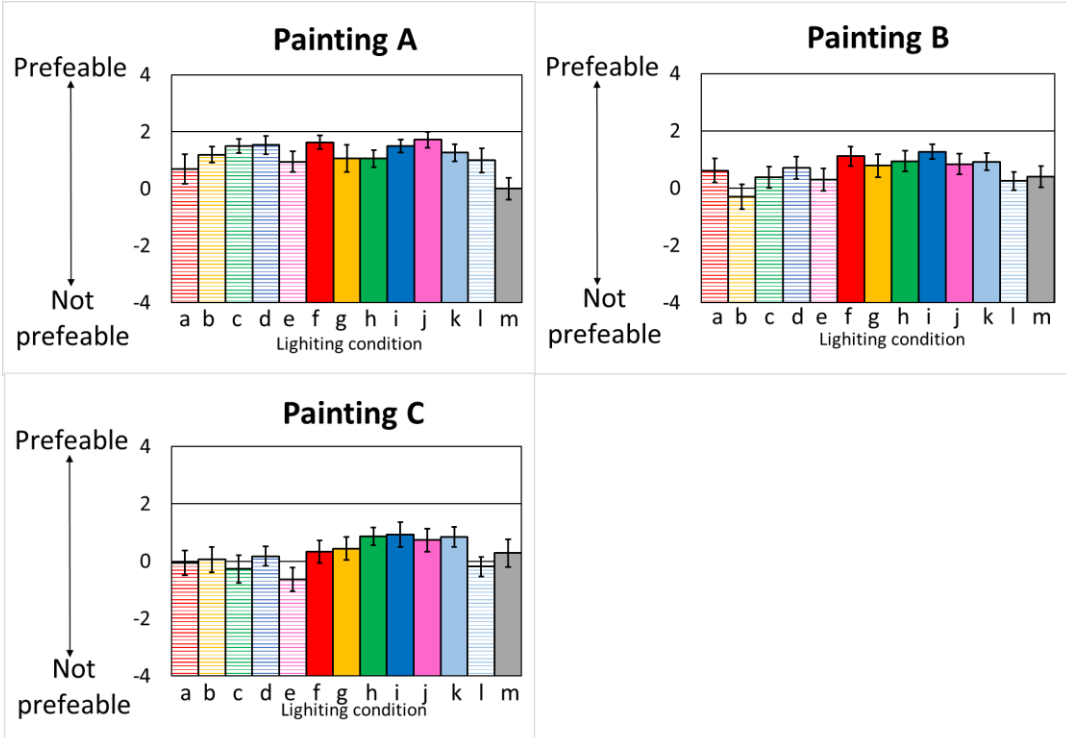

Figure 4: preference of the fluctuation.

Figure 5 shows the preference of appearance of paintings. There were significant differences (<0.05) in the appearance of painting A and C among some lighting conditions. As to Painting A, lighting condition f, j, c, d were highly evaluated, the same as the preference of the fluctuation. In addition to that, other lighting conditions in which CCT on the paintings was kept constant at 5000K were also highly evaluated (condition k, l). As to Painting B and C, lighting conditions that illuminance on the paintings was kept constant at around 200lx had a tendency to be highly evaluated.

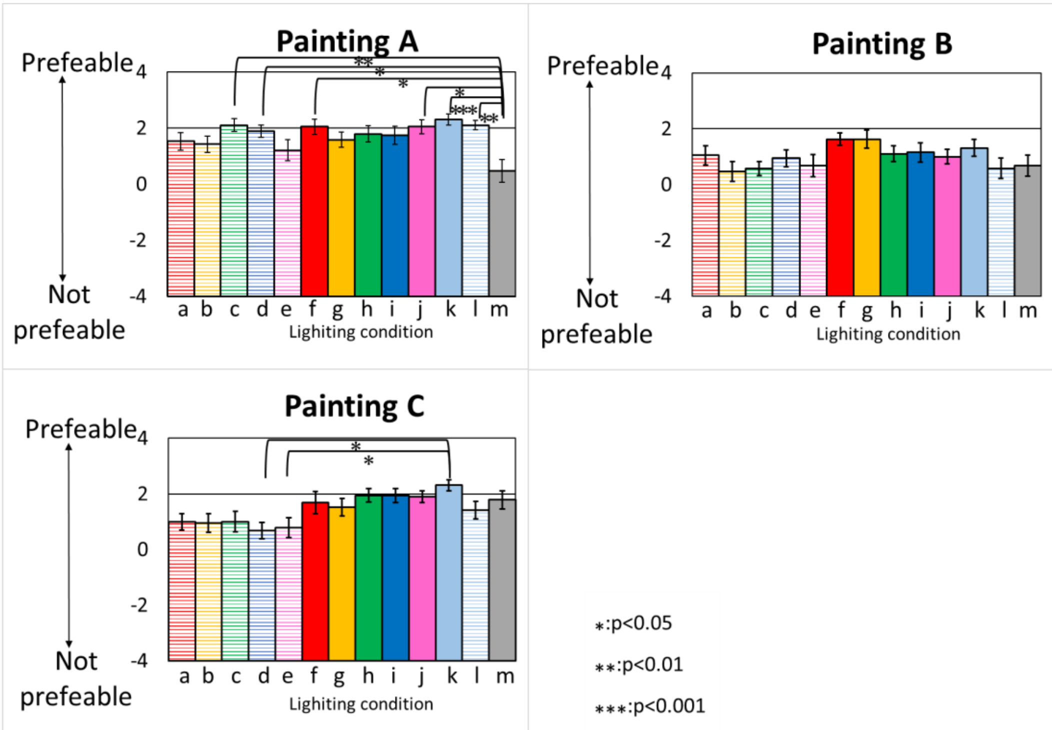

Figure 5: Preference of the appearance of paintings.

CONCLUSION

The results showed that the appearance of paintings would be highly evaluated when illuminance on the paintings was kept constant at around 200lx even under the fluctuation of daylight. However, for a specific painting with low reflectance, even when the illuminance on the painting was lowered, there was a possibility that the evaluation could be kept high if the CCT on the paintings was adequately controlled. In this experiment the CCT range on the paintings was limited. It will be necessary to continue doing further experiments on this issue in future.

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Primary colours as emotional signs for visual design: case study

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ABSTRACT

Each person perceives and feels the primary colours in different ways, but we cannot ignore that each colour has inherent emotional characteristics, and the same can be said about shapes. Attend us to the observation of primary colours characteristics, we developed two studies that are part of the project "Primary colours as emotional signs for visual design", present as case study, at University of Sorocaba, Brazil. The first one was based on a bibliographical survey about yellow and, using design thinking methodology, had the development of compositions with shapes that corresponded to what was perceived as emotional characteristics of the colour. In the second study, students Creative Process classes also developed compositions with shapes that corresponded to their own emotional perceptions of primary colours. In both researches the perceived emotional characteristics of colours were key to development of compositions and the results corroborated Bauhaus's theory of Kandinsky, as presented below.

Keywords: *Colours Signs, Primary Colours, Visual Communication, Visual Design, Emotional Perception.*

INTRODUCTION

Colour is fundamental in our lives, likewise, in visual communication. Colours carry immense symbolic charge and, according to their use, can transmit different messages. Therefore, the knowledge about potential of communication of each colour is fundamental to the correct transmission and interpretation of visual messages, because there is an enormous possibility of colour application and each composition produces a distinct result, as a message of its own.

There are researches and bibliographies to help us to use colours in visual communication, but we know that each country, region or community has cultures and beliefs that presents particularities in emotional perception. For the design field, this particularities in colour perception are fundamental to project and its success in transmission of messages. The second point that drove this research was the difficulty of students to convert bibliography information of colours in images or other visual communication.

To raise afore mentioned interpretation of colours, this research was proposed. The select universe to started was students of Design in University of Sorocaba, in São Paulo state, Brazil. The purpose of research, named “Primary colours as emotional signs for visual design” occurs in two moments: as preliminary study during 2016/2017 and will be proceeding in 2019 as Scientific Initiation Project and, also, is taking place in 2018 classes of Creative Process, of Design course.

A preliminary research starts in 2016 with the yellow. Using mind maps, the student construed signs and, to experiment the results, transformed it in stamps, to serigraphic press. As any other colour, yellow allows an immense range of possibilities to create sign, for that reason, the propose of the student were better tied her own universe. Obviously, final drawings or yellow signs will be validated, but the positive point of this preliminary research was that other students were instigated to propose their own drawings.

During 2018, the second study of mentioned project is being developed: students of Creative Process classes created compositions, whose shapes they judged inherent in the emotional characteristics perceived in the primary colours. They prepared these compositions by experimentation, without previous bibliographical research. The results confirmed Kandinsky's theory, which links the triangle to yellow, the circle to blue, and the square to red. Both surveys will be detailed below.

Should be noted that the final product of the major investigation will be a sign book to inspire student’s projects in visual design field. Therefore, this research corroborates the study on primary colours and its use in visual design projects because it facilitates the students’ immersion in the universe of each primary colour and approximates the understanding of the possible messages that each one transmits, or can transmit, in visual communication.

THE PRELIMINARY STUDY

The project of Scientific Initiation, which paper was the preliminary study of this project, had as premise the investigation of the yellow symbology for design, i.e., we intended to perceive how the yellow appeared in the visual communications. The student made a survey on the internet about how the yellow appeared in concepts and images when it was typed in network search engines. Fauna and flora, industrial products, advertisements, in short, all visual communication that occurred as a result of the searches were visualized.

To filter the numerous images and articles that resulted from this first survey, the student used, as criteria, repetition and relevance to the design. Since the design is a plural area, five aspects were selected to be used in filtering the results of search engines (interface, fashion, interiors, product and games).

The research had qualitative approach and were used two methodologies to proposition of illustration creation to stamping from symbolic interpretation of yellow: Ambrose; Harris (2010) e Noble (2013).

Therefore, the content selected by the student as basis to produce these compositions was converted into keywords and organized in a mind map, following the steps of the mentioned methodologies. Next, we have a table fragment (Table 1) with the keywords and final composition selected (Figure 1).

Search engine	Searched word: amarelo	Searched word: yellow
Google	Meaning, curiosity, September, illness, suicide, creative, July, Geekie games, ENEM, Ipê, apple.	Coldplay, firefly, factory, cosmetics, hair, song, vectors, beauty.
Google Scholar	Plant genetic, passionfruit, coffee leaves, fungi, soil, sewage.	Yellow fever, natives, historical trauma, fluorescent protein, sacred passage.
Periodicals	Brazil, Cucumis Melo, arabica coffee, soil acidity, stability, organic, mineral nutrition, growth, science, abstract ocean.	Scopus, science, technology, engineer, China, protein, infection, luminescence, yellow fever, fish.

Table 1: Fragment of the keyword table created by the student.

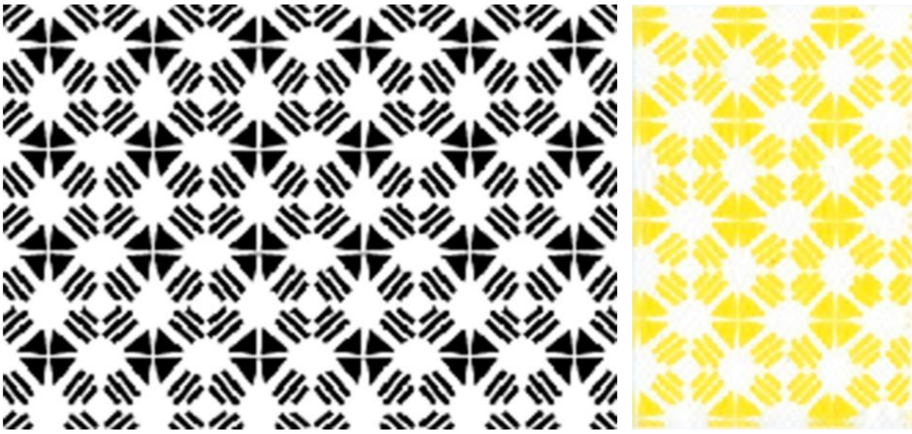

Figure 1: Final composition with shapes inspired by the emotional characteristics of yellow, perceived by the student.

Analysing the student work and the result presented we could note that, instinctively, she was geometrizing her illustrations, which culminated in triangular shapes. This observation refers to Kandinsky's theory (Kandinsky, 2012), which in 1923 stated the existence of a universal correspondence between primary colours and shapes. We can consider that the characteristics cited by Kandinsky refer to the emotional and symbolic characteristics perceived by the student.

PRIMARY COLOUS AND PRIMARY SHAPES

Against the result of the preliminary study, a resumption of the relations between colours and shapes supported by the Bauhaus, we proposed this relation as the starting point for the second study that composes the main research. Maintaining the objective that leads the student to perceive the emotional characteristics inherent to the primary colours and, from them, to create compositions with corresponding shapes, we initiate the Creative Processes discipline in 2018.

Inspired not only in  theory, but also in the Bauhaus didactics of experimentation and later conceptualization, the students began their activities taking knowledge of the chromatic circle of Goethe (Barros, 2006). They produced colours, set up the chromatic circle, constructed chromatic palettes (Figure 2) and, finally, learned theories and concepts involved, such as harmony and contrast, for example.

The experimentation that took place prior to the acquisition of knowledge of the concepts was very important in the creative process, because the students could really notice the harmonious or disharmonious relationships to create their palettes and felt the movement, weight and temperature of the colours, besides the perceived emotional levels, but not always cognized. According Moholi-Nagi cites, innocence elevates creative levels (Lipton and Miller, 2008).

Figure 2: Chromatic circle and relations of harmony and contrast created in experimentation.

From this stage, triangles, squares and circles were given to students, without colour, and asked them to create compositions with shapes that corresponded to what they perceived emotionally in their colour palettes (Figure 3). The purpose was to accustom students to an accurate and immediate perception of shape's compositions and to induce them in a spontaneous disposition to frame all creative thinking in a chromatic-shapes experience, just as occurred in the Bauhaus preliminary course, according to Argan (2005).

Figure 3: Composition with triangles, squares and circles from chromatic pallets.

The importance of this exercise, felt and reported by the students, was the fact that creating with simplified language is much more complex than using elaborate lines and shapes. From the moment that them can propose interesting compositions with primary shapes and colours, students are able to create with greater complexity. We have been able to prove this in the exercises that followed. Chromo-shape compositions have evolved into luminaires, which are very interesting and well-crafted. The emotional information perceived in colours was really used as keys to later creations.

RESULTS AND DISCUSSION

Being know that each person emotionally interprets colours in a particular way, we can perceive that there are certain inherent characteristics in colours. Returning to Kandisnky's concepts, developed in 1923, the three basic shapes and the three primary colours present a series of oppositions; “Yellow and blue represent extremes of hot/cold, light/dark and active/passive, while red is its intermediary. Triangle, square and circle are equivalent graphs of the same polarities[i]” (Lipton e Miller, 2008, P30 e 31).

These concepts were tested and validated by Kandinsky during his stay at the Bauhaus. And this same perception that leads us to make certain chromatic choices in certain shape compositions, or, as happened in both studies presented, to chromatic compositions leads us to the creation of some shape’s compositions.

Design students, usually at the beginning of course, have great difficulty in selecting colours for their project, or creating chromatic compositions that correspond to the message that they wish to convey in their work. However, after the practice of these presented studies, was possible to notice improvement at the cited points and a better creative resourcefulness in the question of primary colours versus basics shapes.

CONCLUSION

Both studies, which based the research “Primary colours as emotional signs for visual design”, followed and stimulated the natural creative intelligence of the students involved. They realized not only the relationship between colours and shapes, but also perceived how and why this relationship happens.

Colours and shapes have dynamics, movement, weight, spatiality and, above all, emotion. Students understood that the choice of colour in the application of a design product should occur at the start of the project because it is responsible for the object perception and the message contained in its visual communication. Although several bibliographies bring these statements and demonstrate them in theories, the experience lived by the students intensified and perpetuated the learning.

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[1] Free translation

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Colour Cultural Study: A Comparison Case Study of Fashion Colour Between China and UK

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ABSTRACT

This project was initiated by Colour Cultural Study Group in Tongji University as part of a colour cultural research agenda, which was funded by Shanghai High Education Academy Research Board in 2017. This case study analyses the colour options, colour similarity and colour names of four fashion brands based on the market of China and UK. This research highlights the international brand promotes a consistent fashion strategy through colour unification; whilst the local brands emphasise the diversity and individuality of colour choices, which reflects the uniqueness of the brand identity. Moreover, the local brands use more sophisticated colour and refined colour rather than conventional colour narratives. All of which are supporting the hypothesis of colour preference is influenced by colour culture, and in turn by segmenting and applying a refined and unique colour quality to clothes, it helps to create and demonstrate a local character of fashion sense.

Keywords: *Colour culture, Fashion colour, Cross-cultural colour study, Colour trend, Colour naming.*

INTRODUCTION

Colour cultural study aims to integrate colour and culture as parallel disciplines to the research of colour meaning and value that contribute the knowledge to culture at different levels. The objective is to provide new perspectives on the fashion colour in China and UK, intending to inform colour cultural study and approached of fashion industries to design. This project will facilitate research on colour culture across the countries that explore the theme of colour culture from ontological, methodical aspects.

Fashion as a form of visual communication has three fundamental functions: information, persuasion and decoration (Barnard, 2002). In semiotics, colour is one of the important signifiers to associate with meanings (Hall, 1997). The colour symbolism of fashion orientates the individual identity and collective belongings that implies and reflects a characteristic of culture. In other words, the colour choice and implementation are determined by culture. In turn fashion trend further cultivates the urban culture and expands the subcultural context.

This study particularly investigates four fashion brands from China and UK, which examines the colour design in a quantitative research approach. The research elevates the understanding of colour and consumption pattern and relevant trend analysis. The comparison case study will reveal the pattern of design and social integration across counties, and relation of commodities colour in a global and local context. Through analysing colour classification, colour similarity, and colour names the research will provide empirical evidence to enhance the understanding of cross-disciplinary research on colour culture.

METHODS

This study is based on the ontological framework of colour culture to conduct a quantitative research. The collected data enhances and reinforces the epistemology of colour culture that forms an empirical experience for constructing theory. The study provides the real-life context for the chosen samples and will help explain the relation between colour design and cultural context. The cases are representative that allow us to concentrate on the specificity and commonality, which is able to apply to any other similar studies. The methods are combined of the following principle research methods:

(1) Case Study will provide empirical evidence for understanding of influential factors that has impact on the colour decisions. These considerations will contribute to construct a theoretical framework for colour cultural study.

(2) Comparison research focuses on the difference and commonality of the samples, which is a dualism measurement for the social and cultural phenomenon. In particular the study investigates the colour classification of fashion, and colour data of the clothes, in order to compare the colour design variations.

ANALYSIS AND FINDINGS

The samples are collected from four brands between the fashion market respectively: Uniqlo (China), Uniqlo (UK), JNBY (China) and Jigsaw (UK). By examining 10 featured SKUs of 2017 women winter collection, the research investigated the date including colour categories, colour options and colour naming from both global and local fashion brands' online shops.

	Uniqlo (China)	**Uniqlo (UK)**	**JNBY (China)**	**Jigsaw (UK)**
01	Ultra light down jacket	Ultra light down jacket	Tweed coat	Storm coat
02	Seamless down jacket	Seamless down jacket	Storm long down jacket	Storm puffa coat
03	Body warm light jacket	Body warm light jacket	Hooded puffa jacket	Hooded puffa jacket
04	Pocketable parka	Pocketable parka	Wool coat	Double face oval coat

05	Ma-1 bomber blouson	Ma-1 bomber blouson	Long tweed coat	One button double face coat
06	Blocktech parka	Blocktech parka	Slim collar coat	Merino milano collar jacket
07	Body warm light bench coat	Body warm light bench coat	Suit wool coat	Grace coat
08	Stretch down vest	Stretch down vest	Windbreaker coat	Trench coat
09	Stretch down coat	Stretch down coat	Hooded down jacket	Windbreaker parka
10	Double face collarless coat	Double face collarless coat	Storm tweed coat	Ring fastening pique cardigan

Table 1: List of samples.

The data collection includes colour options, colour classification, and colour names:

Samples	Colour names	Colour options
UCN 01	Off white, Gray, Black, Red, Wine, Beige, Brown, Olive, Blue, Navy	11
UCN 02	Off white, Black, Red, Navy	3
UCN 03	Light Gray, Black, Pink, Blue	4
UCN 04	Off white, Light gray, Pink, Yellow, Light blue, Blue, Purple	6
UCN 05	Off white, Gray, Black, Olive	2
UCN 06	Purple	4
UCN 07	Light Gray, Black, Blue	3
UCN 08	Gray, Wine	3
UCN 09	Gray, Dark gray, Brown, Navy	2
UCN 10	Dark gray, Red, Beige	2

Table 2: Uniqlo China data collection.

Samples	Colour names	Colour options
UUK 01	Off white, Gray, Black, Red, Wine, Beige, Brown, Olive, Blue, Navy	10
UUK 02	Off white, Black, Red, Navy	4
UUK 03	Light Gray, Black, Pink, Blue	4
UUK 04	Off white, Light gray, Pink, Yellow, Light blue, Blue, Purple	7
UUK 05	Off white, Gray, Black, Olive	4
UUK 06	Purple	1
UUK 07	Light Gray, Black, Blue	3
UUK 08	Gray, Wine	2
UUK 09	Gray, Dark gray, Brown, Navy	4
UUK 10	Dark gray, Red, Beige	3

Table 3: Uniqlo UK data collection.

Samples	Colour names	Colour options
JNBY 01	Black, Iron pink	2
JNBY 02	Black, Khaki, Sands purple, Off white	4
JNBY 03	Black, Off white, Scarlet, Army green, Coffee brown	5
JNBY 04	Mid grey, Navy black	2
JNBY 05	Mid grey, Light coffee brown, Grey navy	3
JNBY 06	Black, White	2
JNBY 07	Khaki, Black, Dark Red	3
JNBY 08	Black, White, Blue, Orange	4
JNBY 09	Dark Navy, Off white, Khaki	3
JNBY 10	Khaki brown, Grey, Black, Bright Red	4

Table 4: JNBY China data collection.

Samples	Colour names	Colour options
JSUK 01	Black, Warm spice	2
JSUK 02	Black, Midnight green	2
JSUK 03	Black	1
JSUK 04	Water mint, Pacific blue	2
JSUK 05	Gravel, Fuchsia, Sugar pink	3
JSUK 06	Sea green, Rock	2
JSUK 07	Camel, Nordic orange	2
JSUK 08	Warn stone, Dark navy	2
JSUK 09	Khaki, Navy	2
JSUK 10	Scarlet, Khaki, Shadow grey	3

Table 5: Jigsaw UK data collection.

RESULT AND DISCUSSION

(1) Analysis of colour options

The colour choices of Uniqlo in China and UK are 4:4.2, which is difference is not obvious, where the difference between JNBY and Jigsaw is 2:3.2 that shows the colour choice of JNBY is more than Jigsaw's. Uniqlo as a global brand provides more colour alternatives than the local brands such JNBY and Jigsaw. The reasons may include:

As the scale of production, it enables the global brands to produce more colour options for consumers. Especially, brands such as Uniqlo regard the variety of colour choices as one of the key design strategies. In contrast, the local brands may be constrained by the production cost and provides less colour options.

The positioning of Uniqlo is fast fashion, which the price and target audiences are middle and lower market, whereas JNBY and Jigsaw as high fashion which the prices are higher than Uniqlo, it may potentially be one of the reasons influencing the colour design as well.

(2) Analysis of colour similarity

The similarity of colour options between Uniqlo China and UK is 52.5%, whereas JBNY and Jigsaw is 11.4%. Through the analysis, it shows the global brands has more similar colour than the local brands.

The global brands emphasise the unity of styles that keeps the consistent colour design across the countries. In China and UK market, Uniqlo remains over 50% same colour in the 2017 seasons design. Nevertheless, in considering the design localisation, Uniqlo provides a few colour options to accommodate and meet the local taste and preference. In the process of global and local culture merge together, colour plays one of the important roles in fashion design.

In contrast, the local brands have low colour similarity, which implies that colour implementation is considered to resist local culture and design. The colour choices may reflect the identity of local people and the characteristics of local colour preferences. Except from black and white, the rest of colours are different from each other. That is to say, colour has become a visual element which to implement the design localisation.

(3) Analysis colour names

In comparison of Uniqlo China and UK, the colour options have more primary colour. As the collected data of winter clothes, the light colour has less than dark colour. The colour names are used more conventional colour naming. Whereas through analysis of JNBY and Jigsaw, it shows that colour names has the distinctive various as below:

- the descriptive colour vocabulary which associate with objects are widely used, such as Midnight green, Sugar pink.
- more secondary colour and shades of hues are used, such as, Light green, Dark gray, Off white, Half toned white.
- the colour names reflecting the character of locality are used, such as Nordic orange, Sands purple.

Through the analysis the local brands compared to global brands are willingly exploring the uniqueness of colour and enriching the design elements and brand personality. By establishing the distinction colour naming system it helps to construct own colour language belong to the brand. The method enhances the understanding of using culture to design, and further demonstrates the close relationship between colour and culture.

CONCLUSION

This study shows colour as a vital element in fashion design and trend. The global brands promote the fashion style through unifying colour design, whereas the local brands emphasise on the diversity and personality though distinctive colour options.

Based on the local consumers' colour preference and colour culture, fashion brands provide the colour options reflecting that colour design is influenced by the cultural aspects. The design elements including colour reflect the local colour recognition, colour psychology and colour language. The use of colour in precision, segmentation, and distinction forms a colour system, which aids to build up a prominent local brand with its culture and fashion sense.

At the same time, the study explores the methods of fashion design in a sustainable way. As the trend refresh and sufficiency in time, the data collection needs to be effective enough to reflect the changes of fashion. The more brands can be included in the future research in order to outline the industrial trend. It will be explored more methods in depth and width in order to reveal the relation between colour and market trend and lifestyle.

In conclusion, the study outlines three key relations between colour and culture: colour and global/local culture, colour and tradition/fashion culture, colour and design culture/mass culture. These elements are the important components to determine the colour culture, in other words, colour culture should include these characteristics of cultural aspects. More importantly, it implies colour culture should be able to reflect the integrated cultural influences in terms of colour meaning interpretations and values. This epistemological knowledge as a theoretical basis of colour cultural study establishes a referential framework to direct the further research.

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Spotting the aesthetically dynamic properties of naturally dyed and finished textiles from a circular design point of view

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ABSTRACT
What if an aesthetically dynamic quality of textile colours and finishing could change our perception of colour as a design element and how could this happen?

This paper aims to respond to the above-mentioned question presenting new insights based on experiments with natural dies and finishing. First, and based on scientific evidence, it is described how the use of natural dyestuffs can result in novel textile properties introduced as so-called dynamic quality of textile colour and finishing. Second, the experimental settings in which textiles with dynamic impact could be achieved are described. Third, an outlook is presented with possible application scenarios for such textiles with dynamic characteristics.

Within this framework, it is suggested that the dynamic colour properties are no longer considered as a failure or damage but closely linked to product concepts in order to satisfy customer experiences which may differ from standard textile products.

Keywords: *Dynamic colour properties, Circular design, Natural dyestuff, Natural finishing, Sustainable product strategies*

INTRODUCTION

Imagine, the colour of our new pullover is achieved by natural dies, the product is developed based on a circular design thinking in manufacturing and, therefore, has different qualities, which are only revealed while using and wearing the garment. Its colour is not permanent, as most customers would expect their clothes to be, but interacts slowly and metamorphically with influences from the environment such as light and water affecting the shine, brightness and saturation of its colour appearance. The user is informed about this novel property of the product in order not to consider its changes as a failure. If the colour characteristic is creating an added value as a specific design element, the user may find himself discovering and observing its dynamic, evolving features. As a result, he can see the beauty of natural changes and variations in the product, making it over time unique and personal. Unfortunately, this portrayed scenario has not yet become true and explains one of today's relevance of textile and material research: to outline and develop solutions on how materials and textiles could be designed in order to respect and integrate the conditions of our living environment.

The goal of this paper is to make suggestions on how the gap between today's user expectations (products should perfectly stay the way they are when we purchase them) and the above-mentioned scenario can be cultivated. We are sharing insights which we gained in the last five years in textile research in several applied research projects together with industry partners funded by the Swiss Government (Innosuisse). Between 2014 and 2017, we particularly reflected the textile and garment manufacturing process from a circular design point of view and with given criteria from the industry partner–that the textiles have to be fully vegan (excluding all animal fibres) and bio degradable. After use the textiles are meant to become suitable soil to grow plants on.

To enrol the discussion more deeply about design potential of so-called aesthetically dynamic properties of naturally dyed and finished textiles, it is necessary to first define terms outlining the theoretical background. Then we present finishing experiments with natural dyestuffs, which will lead us to draw an outlook with future scenarios.

THEORY

The Circular Economy Theory defines a process from the beginning to the end as a circle with the minimum requirement of input and the longest possible cycle (Webster, 2015). If we apply this on the development and life cycle of textiles and garments, the existing standards are mostly not fulfilling these requirements. This circular approach is as well redefining the product user relationship. It features the use, care and customization of garments. The aspect making a person love garments is in most cases the traces which are telling stories of life (Fletcher, 2016). Historically as well as in present times, the topic of natural dyestuff has been systematically elaborated in several research projects. The availability of natural dyestuff is now assured through a range of several companies which are beginning to implement industrial processes using natural dyestuff. (Stern, 2016).

Furthermore, the state-of-the-art shows that many authors recognize the beauty of natural colours. Their properties though are always compared to the chemical dyestuff used in the textile industry. Therefore, natural dyestuff is competing with the existing standards, instead of establishing standards of its own.

We understand the definition "dynamic" in terms of textile colour as a design element being affected by environmental influences (e.g. Mischer'Traxler Studio, 2008). In our case the meaning of the word dynamic is related to a long-time setting and irreversible and continuous environmental influences. Our framework excludes other short-time related dynamics with instant change of colour, for example by change of temperature (thermochromic pigments) or change of observation perspective (Hologram, Irisé). From a design point of view the traces which are telling stories is a given quality by nature.

EXPERIMENTAL

The series of experiments were designed to investigate the feasibility and the aesthetic effect of screen printing based on natural dyestuff, fulfilling the initially mentioned criteria. The samples presented show four basic tones selected out of 49 colours. In addition to testing results (colour fastness), the working process has led to the later proposed sustainable concepts. The experiments have been conducted as follows:

Procedure

As an inhouse expert of dyestuff and pigments, Anita Wanner was part of the project group and was leading the experiments which were all carried out in the textile workshops and the "Studio for Colours" in our Department Design & Art.

1. Preparation of printing paste: The printing paste consisted of a mixture of 5% natural dye powder from NIG Nahrungs- Ingenieurstechnik GmbH, such as presented in this paper "Wau", "Krapp", "Hema" and "Green", and 95% of the thickener "Prisulon 1570" from CHT Germany GmbH. The components were properly mixed and left overnight.

2. Pre-Treatment of fibres: Due to the criteria given by the industry partner, only fabrics and knitwear made of cellulose fibres such as linen, cotton, hemp and modal have been printed. The following procedures are based on instructions by Wipplinger (2005). Compared to other instructions as for example by Liles (1990) are her descriptions less time-consuming and more energy-saving. After steaming and washing, the printing results have shown beautiful, intensive colours. The influence of different mordants on the fastness has not yet been tested.

2a. Scouring: As a first step, the fabrics were washed in boiling water with liquid scour and soda ash to remove unwanted residues such as waxes and pectin.

2b. Mordanting: In a second step, the fabrics were mordated in a water bath with 5 % wof (weight of dry textile) aluminum acetate for one hour at 40°C.

3. Screen printing: A polyester printing mesh with specification 48-70 (thickness of thread - threads per inch) was used. The dry and ironed fabrics were printed with double pulling.

4. Steaming, washing: The printed and dried fabrics were steamed at 103°C for 12 minutes. Afterwards, the materials were first washed out cold until the printing paste was completely removed and then washed again in a washing machine at 40 -60°C.

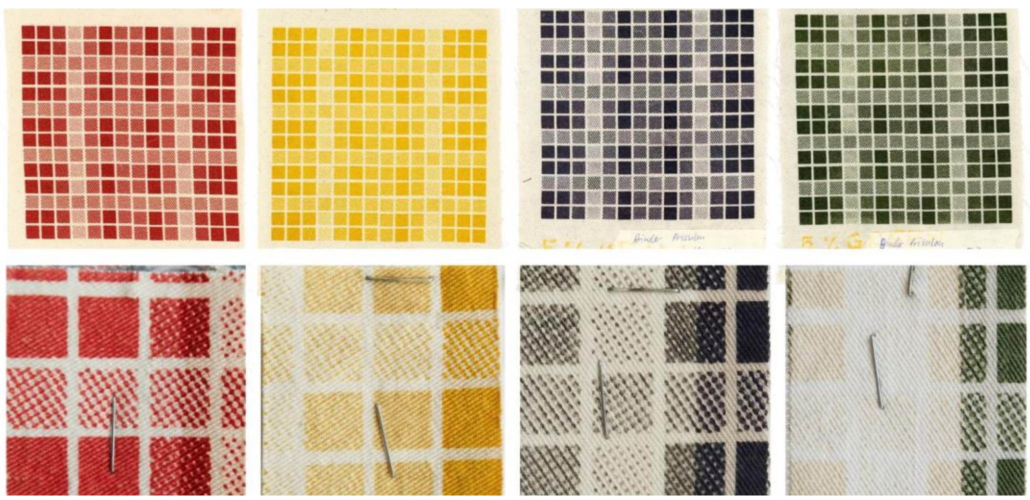

Figure 1: Samples D1 Krapp/ D2 Wau/ D5 Hema/ D6 Green; low line: colour change with light.

Test Results	D1 Krapp	D2 Wau	D5 Hema	D6 Green
Colour fastness to artificial light, SN ISO 105 - B02	3.0	4.0	3.0	2.0
Colour fastness to washing SN ISO 105 - C01	Item: 3.0 CO:4.4 CV: 4.3	Item: 3.8 CO: 2.4 CV: 2.9	Item: 1.9 CO:4.8 CV: 4.7	Item: 1.0 CO:4.4 CV: 4.6
Colour fastness to rubbing SN ISO 105 - X12	Dry: 4.7 Wet: 3.1	Dry: 4.9 Wet: 4.2	Dry: 4.7 Wet: 3.2	Dry: 4.6 Wet: 3.3

Table 1: Test results colour fastness.

RESULTS AND DISCUSSION

From a design point of view, we are interested in the use of natural dyestuff and how it potentially affects the entire fashion network including designers, brands, suppliers and, as the most important player, the customers themselves. Although it is difficult and complex to reframe existing standards, a strong design vision can do so. Let us feature here the original Blue Jeans as a good garment example with dynamic textile colour properties, as it is well received by a wide customer base. What can we learn from this garment which seems to gain more value through its change in use? It's a matter of consideration. As we understand design as an enabling science (Buchanan, 1998), we are linking existing material knowledge to reflections on the product user interaction and finally provoking radical thoughts triggering the western social framework of values.

We are describing three main aspects for future scenarios based on the dynamic characteristics of textiles, then expanding the setting from product to the dimension of product responsibility towards and the recognition of such on a cultural level. If the use of natural colours in a garment is to create sustainable added value, it is essential to structure the process on the basis of circular design thinking including social, economic and ecological aspects in the decision-making process. The designer is faced with a complex starting point, which can only lead to a good design if he or she takes the following aspects into account.

1) A textile product is an invitation to the user to observe dynamic colour changes over time and to enjoy its fading away (Koren, 2008):

If we look at the fashion community, many suggestions have been made on how to change the fashion paradox (Black, 2008) into a more sustainable economy. What has not been pointed out so far is the fact that dynamic colour properties could be a particular aspect asking for specific designs in order to create valuable and long-lasting products. The beauty of change and variation could be the key to a strong and emotional bond between user and product. What if the combination of different light sensitiveness in one textile design and it’s finishing could result in novel textile materials which change metamorphically depending on the different influences of the environment? The design shows two colours (Wau or Krapp combined with Green) in the beginning and will change over time into a design based on one remaining colour after the other has vanished?

2) The responsibility of fashion brands and companies does not stop after having sold a product:

If a company is striving to develop sustainable products, then the customer needs to be introduced properly to the specific product characteristics. If e.g. the colour of a product is changing, the customer needs to be informed about its wash and care. How can the consumer influence the product's life cycle and in particular experience its dynamic colour properties? Communication is the key to introducing the dynamic properties of naturally dyed and finished textiles along with it their specific look. The challenge is to find simple ways to make the inherent yet invisible dynamic characteristics visible when buying the product. Present and future efforts in product development should not be limited to considerations regarding measurable objectives but include user responsibilities within the entire product life cycle (Webster, 2015). The efforts must shift from not only designing the final product, but also designing product user relationships including its aging over time (Koren, 2008).

3) Natural changes and variations in product appearance should be valued, referring to the constantly changing state of our personal life and the environment.

Our world is constantly changing, how can we expect any part of it (surfaces, goods, materials etc.) to remain unchanged? In research projects with industry partners, we understand how difficult it is to introduce new colour standards, because market tolerance is nominal and customers expect the colour of a purchased product preferably not to change at all during use and care. Therefore, the designer's role is virtually important to deliver combinations of sustainable aspects with product characteristics that are accessible to the user. The design should at best reveal the original material properties as such (Soentgen, 2014).

CONCLUSION

The user, who considers dynamic colour changes in terms of textiles in a personal way beneficial can initiate the transformation of the established perception of colour properties on a supplier's side. Moreover, and from a circular point of view in the design process, these particular dynamics have to be treated as a design element. It can only create added value, by refining the attractivity of a product throughout every stage of change while constantly fulfilling the initial design idea.

ACKNOWLEDGEMENTS

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Colour and Lighting

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The Effect of Coloured Glazing on Thermal, Visual and Overall Comfort Evaluation

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ABSTRACT

Within the scope of a broader research project about visual and thermal interaction effects on human comfort and perception, the aim of this paper is to study the variation of thermal, visual and overall comfort votes of people exposed to blue and orange glazing. The study, conducted in a controlled test room and involving a total of 75 participants, is repeated at three temperature levels to investigate whether variations in comfort votes are affected by the thermal environment. Results show that participants changed their comfort votes for both thermal and overall comfort, beside the expected visual comfort, due to changes in glazing colour. Larger variations in thermal and overall comfort votes are observed in the close-to-comfortable temperature range (22 °C). Temperature-related effects can be seen for visual and thermal comfort evaluations. Overall comfort shows a positive correlation with both visual and thermal comfort.

Keywords: *colour, temperature, visual comfort, thermal comfort, overall comfort.*

INTRODUCTION

Colour is an essential aspect of the built environment that characterises the whole indoor ambiance, from small objects to the permeating light. Colour, besides affecting the visual perception of people, can also influence other types of perception, such as the thermal one. The specific influence of coloured stimuli on human thermal perception is referred to as the "hue-heat-hypothesis" (Bennett and Rey, 1972) and has gained attention for building design and operation due to the fascinating idea of heating and cooling with colours. A recent literature review by the authors suggests that the colour of light can have a bigger impact on the thermal perception of people compared to the colour of objects or of room surfaces (Chinazzo *et al.*, 2018a). The colour of the incoming daylight resulting from both direct sunlight and diffuse skylight, changes its appearance due to variations of its spectrum according to weather, time of the day and season (Judd *et al*., 1964; Lee and Hernández-Andrés, 2005), but also because of the window's spectral transmittance properties. The role of glazing's properties (in particular, its colour) and the resulting transmitted daylight (from now on referred to as "coloured daylight") becomes therefore an important factor to study for the understanding of not only the visual perception of the indoor environment, but also of the thermal perception and the overall comfort of people.

The present study is a part of a larger research project aiming to understand the interactions between visual and thermal factors on human perception. In particular, visual (i.e., colour) and thermal interactions are investigated by means of experiments in a controlled environment that allows to set, change and monitor the indoor temperature and the coloured daylight by means of coloured glazing. The main findings about the effect of coloured daylight on thermal perception and the effect of temperature on visual evaluations can be found in Chinazzo *et al*. (2018b, 2018c). This paper focuses on comfort evaluation only, considering thermal, visual and overall comfort together. It first analyses the comfort vote variations according to coloured daylight (differences between blue and orange) to see if the change of glazing, other than affecting the visual comfort, has an impact on thermal and overall comfort as well. Those variations are studied at three temperature levels, to investigate whether also the thermal environment plays a role in the evaluation. Finally, the paper investigates the correlation between the three types of comfort.

EXPERIMENTS

A total of 75 people participated in the experiment conducted from November 2016 to April 2017 in a semi-controlled environment (i.e., a test room where temperature is controlled by means of a radiant system, whereas light is subjected to changes due to the time of the day, climate and season as only daylight is taken into consideration). Details are described in Chinazzo *et al*. (2018c). All participants experienced three types of glazing, two coloured (blue and orange) and a neutral one presented in a randomized order, and just one of the three temperature levels investigated (19 °C, 22 °C or 26 °C). Each experiment lasted three hours and participants experienced each colour condition for 30 minutes (considered as a short exposure time), while exposed to the same temperature range for the entire experiment. Thermal adaptation occurred in the first part of the experiment, when participants were exposed to electric light for 45 minutes. Participants reported their subjective evaluations about thermal, visual and overall comfort on the same five-point semantic differential scale (from very uncomfortable to very comfortable) at the end of each colour exposure. Two types of visual comfort questions were included in the investigation, referring respectively to the evaluation of the colour of the light and the general visual environment. We will refer to them as colour comfort and general visual comfort, respectively.

RESULTS AND DISCUSSION

Given the experimental design followed in this investigation and the fact that all the participants experienced the three glazing types, this paper addresses the difference in visual, thermal and overall comfort votes between the two extreme coloured daylight conditions, the blue and the orange. The following results and discussion report a comfort vote variation following equation 1, calculated for each participant.

$$\boldsymbol{comfort\ vote\ variation} = \boldsymbol{comfort_{blue}} - \boldsymbol{comfort_{orange}} \quad (1)$$

Considering that comfort votes range from 1 (very uncomfortable) to 5 (very comfortable), the maximum difference between the two votes is 4. A comfort vote variation equal to 0 indicates that participants did not change their comfort vote under different colours. Positive values illustrate that participants rated the comfort under the blue condition more positively than under the orange, whereas negative values indicate a more comfortable condition under orange compared to blue.

Figures 1, 2 and 3 illustrate the distribution of thermal, visual and overall comfort vote variations between blue and orange coloured daylight, at three temperature levels.

By looking at figure 1 it appears clearly that thermal comfort of participants was affected by the coloured daylight. In particular, thermal comfort was evaluated higher under the orange condition compared to the blue one by 40% and 44% of participants exposed to 26 °C (considered “neutral” in the corresponding thermal sensation scale) and 22 °C (considered in between “slightly cool” and “neutral”), respectively. The percentage decreases under 19 °C (considered in between “cool” and “slightly cool”) and it equals the one indicating more comfortable conditions under the blue light. Results suggest a temperature-related effect, with orange glazing evaluated as more comfortable under comfortable (26 °C) or close-to-comfortable (22 °C) temperatures.

For the visual comfort, we found – as expected – that the comfort related to colour of participants was affected by the coloured daylight. What is interesting to point out, by looking at figure 2, is that results are effected by the thermal environment. Orange is considered a more comfortable colour compared to blue at 19 °C (by 44% of participants) and at 22 °C (by 52% of participants), whereas the percentage of people considering blue a more comfortable colour than orange increases with temperature, with 44% at 26 °C compared with 12% at 19 °C. Also, results here suggest a temperature-related effect of colour on visual comfort evaluation, in terms of comfortable colour conditions.

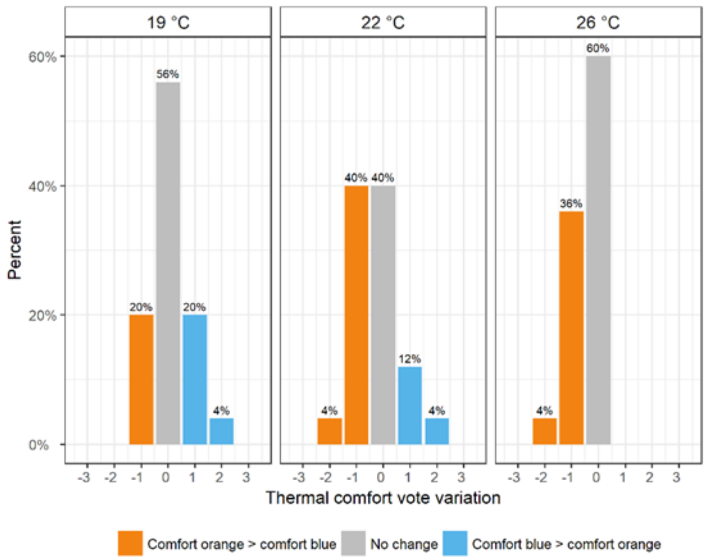

Figure 1: Thermal comfort votes variation between thermal comfort votes of participants exposed to blue daylight and the thermal comfort votes of participants exposed to orange daylight.

The overall comfort variation (figure 3) is affected by colour but it does not show changes of votes that would have indicated a higher overall comfort under a particular colour (the negative and the positive differences are always similar), nor a temperature-related effect. On the other hand, the variation of votes is larger at 22 °C, whereas it is smaller at 19 °C and at 26 °C, in which the majority of participants did not change the overall comfort vote at different colour exposure (variation equals 0). The same observation can be done for the thermal comfort variation (figure 1). This result suggests that the effect of colour on thermal and overall comfort might be stronger in a temperature range considered as close-to-comfortable (22 °C) and the effect of temperature might predominate at temperature ranges considered as comfortable or slightly outside of the comfort zone. Regarding comfort related to colour, the variation in comfort votes is smaller in the cold temperature condition, meaning that the effect of the colour on a visual-related scale is lower if the temperature is slightly outside of a comfortable zone.

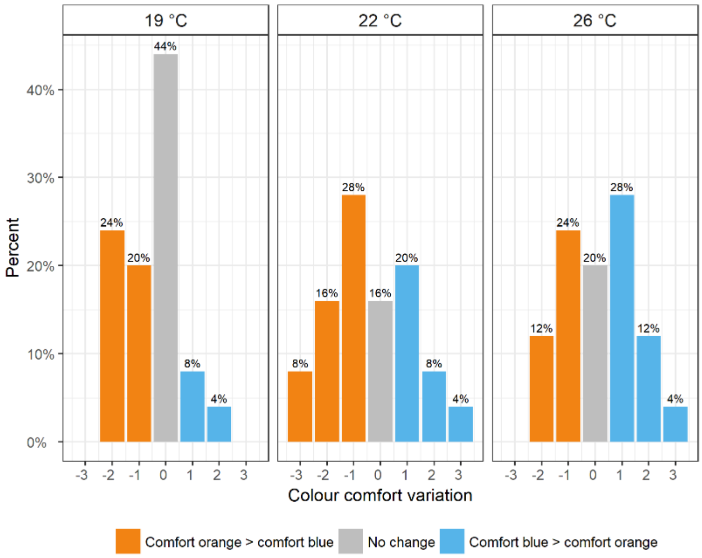

Figure 2: Visual comfort votes variation (in terms of colour evaluation) between colour comfort votes of participants exposed to blue daylight and the colour comfort votes of participants exposed to orange daylight.

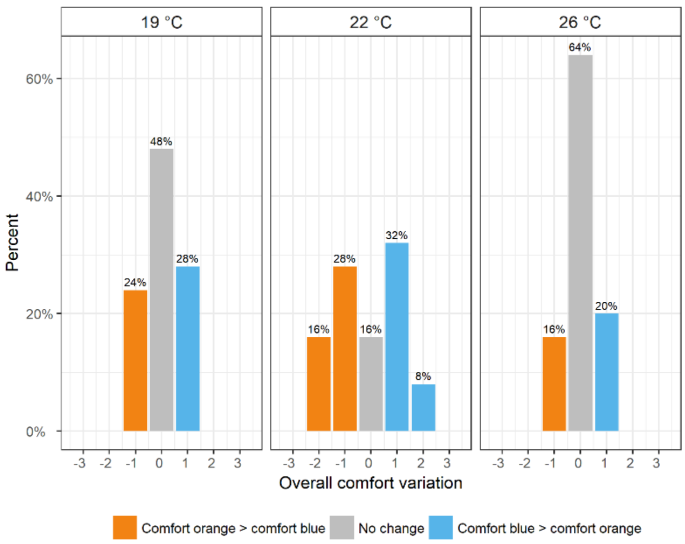

Figure 3: Overall comfort votes variation between overall comfort votes of participants exposed to blue daylight and the overall comfort votes of participants exposed to orange daylight.

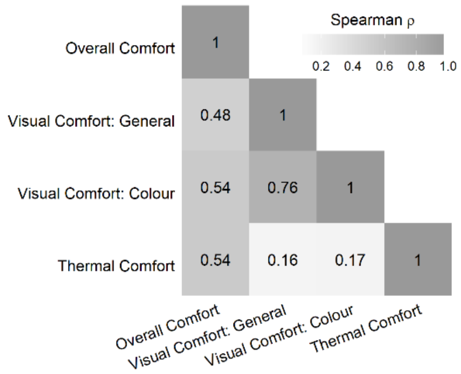

Figure 4: Correlation matrix between overall, visual (general and colour) and thermal comfort.

Figure 4 illustrates the correlation matrix with the Spearman correlation between the three investigated comfort votes: overall, visual (general and colour) and thermal. This time, all the votes at all temperature levels for all three coloured glazing (neutral, blue and orange) are included in the analysis. It is possible to see that the overall comfort positively correlates with both thermal and colour comfort in a comparable way, a result that seems in contrast with previous studies, where overall comfort was mainly related to thermal comfort (Buratti *et al*., 2018; Frontczak and Wargocki, 2011; Kim and de Dear, 2012). A possible explanation for the contrasting results is the nature of the experiment, in which both thermal and visual parameters were the only factors varied across participants, resulting in the two principal factors strongly correlated with the overall evaluation. Thermal and visual comfort do not correlate and only 76% of the variation in colour explains the variation in the general visual environment, highlighting that colour, despite being a strong attribute of the visual environment, was considered along with other factors in the general visual comfort evaluation.

CONCLUSION

This paper illustrates that changes of coloured glazing resulted in changes of thermal and overall comfort, other than of foreseeable changes of visual comfort. Moreover, results show temperature-related colour effects regarding visual and thermal comfort evaluations. In particular, orange glazing led to more comfortable thermal conditions than blue glazing, especially at comfortable (26 °C) or close-to-comfortable (22 °C) temperatures. Orange glazing also led to higher colour comfort compared to blue glazing at slightly uncomfortable (19 °C) and close-to-comfortable (22 °C) thermal conditions, and preferences with blue daylight over orange daylight increased with temperature (from 12% at 19 °C to 44% at 26 °C). Despite changes in colours led to changes in overall comfort, neither blue nor orange resulted in more comfortable overall conditions. Variations in thermal and overall comfort votes between the blue and the orange conditions were larger in the close-to-comfortable thermal condition (22 °C), highlighting a stronger influence of temperature in the other thermal conditions. Variations in colour comfort votes were larger at comfortable (26 °C) and close-to-comfortable (22 °C) thermal conditions, meaning that the effect of colour on a visual-related scale is lower if the temperature is slightly outside of a comfortable zone.

Overall comfort positively correlated to both visual and thermal comfort in a comparable way, due to the experimental design and the fact that colour was a strong attribute of the indoor environment.

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Visual Experience of Older Adults: Colour Preference and Colour Tuning for Health and Comfort

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ABSTRACT

Understanding visual conditions of the aging population helps us to define major challenges faced in navigating space and living healthy lives. For older adults colour and light can be used strategically to improve quality of life. Incorporation of daylight and electric light into the built environment can help compensate for the diminished visual system and lifestyle changes of the older adult. One of the biggest trends in lighting is the development of colour tuning LED fixtures. Is incorporating tunable white LED fixtures in people's homes the advisable route for aging adults? If a spectrum of the light is makings colours look less attractive to them, should the source change to make colour more vivid and interesting Or conversely, is the best route to change the colour in a space, for example using the aging person's preferred colours in paint colour, objects and fabric of a space?

Keywords: *Aging, Lighting, Health, Built Environment, Technology*

INTRODUCTION

Biological and environmental factors influence the older adult's spatial orientation, object recognition and social behaviour. Conscious use of colour and the use of new lighting technologies can help compensate for the diminished visual system and lifestyle changes of the older adult.

Lighting is not neutral in terms of human health, and adverse effects, such as disturbance of sleep/wake cycles, mood disorders and possibly even cancer pathologies may be the consequences of ignoring new findings on non-visual effects of light. Improving lighting quality has a known impact for vision and health and quality of life. Therefore, there are possibilities for application in nearly all situations of our daily lives.

An environment which hinders our everyday life more than it supports it will often result in psychological effects such as stress and fatigue. Meanwhile, it is also known that many older people have a lower threshold for stress, which further intensifies the demand for a clearly and easily interpreted environment. A well-functioning and easily interpreted life environment is in balance with our abilities and support everything that pertains to life. The quality of the visual environment is very important for older adults affecting their overall well-being and safety.

THEORY

THE AGING EYE

Many of the aging changes in vision come from within the eye, from the structures that modulate the transmission and initial processing of images. There are also changes in the brain where images must be interpreted. For consideration in this paper we look at the changes in vision in the normal healthy aging eye. Though there is a large variation between individuals on the rate and degree of aging of their eyes, the processes of aging remain the same.

-Thickening and yellowing of the lens. Up until approximately 25 years of age 70-85% of the visible spectrum reaching the eye also reaches the retina. As we grow older, transmittance at all wavelengths is reduced, along with a significant reduction in short wavelength radiation transmitting.

- With age the eye's lens loses its elasticity and the muscles that control its contractions are weakened. The lens can no longer accommodate and adapt to different visual circumstances, which leads to a reduction in ability to focus and make out fine details. Less clarity (the images that are formed in the back of the eye are less sharp) and there is peripheral vision impairment.

-Pupil size becomes smaller and less responsive to changes in light conditions. There is an inability for the older eye to increase and decrease pupil size based on ambient light levels. Less light gets to the back of the eye therefore needs much more light to enable person to perform tasks. Dark adaptation slows- it takes much longer for eyes to adapt from going to a lit space to a dark space or a dark space to a lit space.

-Signs of aging in the retina is decreased visual acuity, declining sensitivity of visual field, decreased contrast sensitivity and increased dark adaptation threshold.

-Iris- loss of pigment. Slowed response to sensory stimuli (light and dark)

-Inability of cones photoreceptor to block the signal from the rod photoreceptors during high light levels causing discomfort glare.

-Vitreous humour shrinks; build up of proteins; more prevalence of floaters

-Reduction in neuron density. Limited image enhancement (harder to recognize faces), motion perception impairment.

COLOUR DISCRIMINATION, PERCEPTION AND PREFERENCE: AGING EYES

Colour is a powerful sensation that brings variety and emotion to our world. The way we experience form, depth and movement rely on our perception of brightness or luminance, saturation and hue. Ultimately visual awareness is a combination of hundreds or thousands of luminance sensitive cells responding primarily to edges and contrasts to define form and depth, with a colour map superimposed. Our conscious perception integrates all these aspects of vision so that we can recognize and interpret characteristics such as texture, form, depth, facial expression, and complex movements.

Colour vision is affected by natural aging processes. Colour discrimination gets worse as we age. It may be a matter of difficulty to differentiate between colours that are similar in lightness, or to see differences in hue and chromaticity. This particularly applies to colours within the blue and green colour areas and the difficulties become most prevalent when these colours have similar value. Differences in lightness are the most easily perceived, but when the eye ages it requires increasingly intense contrasts to be able to differentiate between hue. This has practical consequences in small and everyday things such a pouring coffee into a dark brown cup on a dark brown table. It can be harder to tell the difference between two socks or two similar pills of slightly different colour. It may disorient an individual by not seeing differences in floor levels because of decreased depth perception due to lack of contrast.

Knowledge of colour perception in old age can be of value when using colour contrast, cues and codes in the environment to promote orientation and function. According to the 1999 study Colour discrimination, colour naming and colour preference in 80-year olds, Wijk H,Berg S, Sivik L, Steen B, their colour naming test indicated that the colours white, black, yellow, red, blue and green promoted recognition to the highest degree among all subjects. Colour discrimination was easier in the red and yellow area than in the blue and green area. The preference order for seven colours put blue, green and red at the top, and brown at the bottom, hence agreeing with earlier studies, and indicating that the preference order for colours remains relatively stable also in old age.

TUNABLE WHITE LED TECHNOLOGY

White tuning LED fixtures allows for changing the colour of light from warm to neutral to cool in appearance. Some white-tunable products, also called tunable white or Kelvin changing, have two sets of controllable phosphor-coated (PC) LEDs: one with a warm-white colour (usually around 2700K) and the second with a cool-white colour (usually 5000K to 6500K). By individually raising and lowering the output of the two coloured “LED primaries”, white colours between the two colour points can be created along the straight line that connects them on a chromaticity diagram (this is called linear white tuning). When only two white PC LEDs are selected, the manufacturer must choose where the mixed colours of white will lie, relative to the blackbody curve. Will the colour of white light appear pinkish or purplish as it tracks from one CCT to the next? The blackbody line is curved, so two colours of white cannot track along the blackbody and, the wider the range of CCTs, the greater the maximum deviation from the blackbody (Duv). There are also white-tunable products that use three or more LED primaries, in which case they may have the capability to produce a wider range of colours than just different CCTs of white. However, such products may operate in a mode that allows only colour change along the blackbody locus. The advantage of white-tuning products with three or more LED primaries is that they track the curve of the blackbody (called nonlinear white tuning). Some of these products closely track the blackbody curve throughout their tuning range (i.e. their Duv values can be very small), meaning they will not appear green or pink compared to a reference light source whose chromaticity falls right on the blackbody curve.

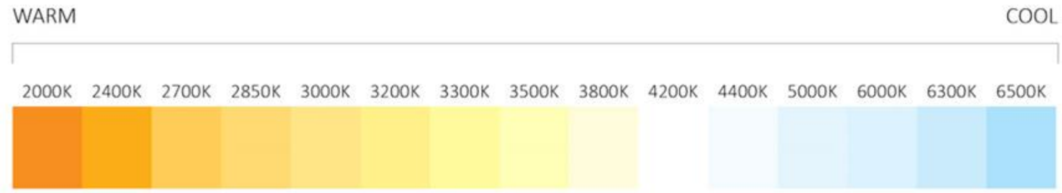

Figure 1: Possible range for Correlated Colour Temperature (CCT) for tunable white LED fixture.

DISCUSSION

Effective use of lighting and a conscious and enjoyable use of colour can lessen the impact of the natural deterioration of the visual system. The most important uses of light that can improve quality of life and enable optimal vision is to increase of the quantity of light to the eye and to ensure high colour rendering of the light source. The ability to adjust correlated colour temperature with white LED colour tuning technology can help to regulate our circadian system and enhance our colour vision.

Quantity of light and spectral sensitivity is critical for the regulation of the circadian system. If you get light at the wrong time or if you don't get enough light at the right time or if you are in a constant dimly lit environment light can be a major circadian disrupter. Poor sleep, poor performance, higher stress, increased anxiety and depression, cardiovascular disease, type 2 diabetes, higher incidence of cancer can be consequences of a disrupted circadian system. Tunable light sources can be adjusted to optimize the lighting requirements for circadian entrainment. Light levels, spectrum, timing and duration of exposure must be considered. Robust dark/ light patterns ensure people sleep better at night. We want high circadian stimulus in the day time. Low circadian stimulus in the evening/night time.

Contrast is a big issue for older adults. The use of colour in the environment needs to be intentionally applied to demarcate the space. It's not the saturation of the colours that is the issue, it is using colours that are highly different in value that help to distinguish objects on a counter or lead the eye to a door or support handle. Colour discrimination gets worse as we age and colour become harder for the elderly to distinguish in either dim light or very bright light. Cognitive changes make us less tolerant of visual clutter. It makes it harder to detect the things we want or need to see.

As we age, even healthy eyes become more sensitive to glare-they require higher contrasts to see than they did when we were younger. It is important when you are delivering the light to deliver in a way that you're are not increasing disability glare which reduces the contrast in the back of the eye. The need for higher light levels also means that control of sources of light is especially important. The use of coves, shades, valances, wall washing, uplighting ceilings all help to deliver light with less glare.

Food and meals are important aspects of well-being. With rising age, you often experience lower appetite. Food looks more appealing when it is lit with enough light and good colour rendering. Proper lighting levels help with safe food preparation. Colour and value contrast can be used to enhance food, for example garnishing (white) potatoes with (green) parsley. As well, using coloured tools for food preparation makes it easier to spot on the counter or in the drawer. Items such as coloured spatulas and brightly coloured knife handles are commonly available.

Colour preference is subjective and usually what we like when we are younger, we like in older age. According to current lighting studies it is found that there can be wide differences from one person to another in preferred light source spectrum.

The advantage to using colour tuning LED fixtures is so that individuals can tune the light to their personal preferred colour. Personalized lighting in the form of colour tuning task lighting can be beneficial to those living with other people where there is a negative impact of personal lighting preference. "We become the author of our light", Carlotta de Bevilacqua.

CONCLUSION

Though the natural trend for older adults is for the visual system to deteriorate over time, the rate and degree of decline vary significantly among individuals. There are also wide differences from one person to another in preferred light source spectrum. Lighting and colour designed with older adults needs in mind can help them see better, sleep better, feel less depressed, eat better, have better postural control and stability and have more enjoyment out of life. Technology is available now to implement these important design solutions. Spectrally tunable light can be a way in which people can have the conditions they like and that in itself has benefits for well-being. An important aspect is for the person to independently be able to adjust the light's intensity, direction and distribution in their life environment. That said, these systems are complex, and the control interfaces are often confusing even to an expert. The benefits for white colour tuning light for personal use is clear, however issues with controls and cost is still problematic. There is a research and development gap on controls usability for various populations that needs to be filled. A need for quality control of LED's will also ensure that colour rendering and colour constancy is maintained. According to trends in lighting seen at Light + Build 2018 there are features for regulating the colour temperature of luminaires with user friendly app's or controllers. You can also adjust the temperature of light with a wave of a hand. Future developments include a light logger that you can wear to control your personal lighting. Further study into spectral distribution and colour preference and further understanding of the biological, psychological and the emotional effects of light will enhance our understanding of lighting and the use of colour for improving the environment of the older adult.

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Impact of the artificial lighting's colour temperature on the elderly's circadian cycle

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ABSTRACT

Age leads to a natural evolution of the circadian cycle. For the elderly some changes in chronotype can be observed. This leads to a decline in the quality of sleep and a state of daily sleep. It's actually a question of compensating the changes of the circadian cycle by the use of the light. It does a major role in its regulation. If blue light allows stimulation of brain activity, a yellow light can trigger a resting and a sleeping phase which recreate the benefit of the chromatic cycle of natural light. Accompanying the elderly in their daily lives, this dynamic compensates the evolution of their circadian rhythm. The study of dynamic LED lighting has made it possible to judge the potential of artificial lighting to reproduce the colour and the cycle of natural light. This "Human Centric Lighting" becomes a factor for improving the elderly's pace of life to ensure a standard of living.

Keywords: *Aging, Biodynamic lighting, Chromatic Cycle, Comfort, Daylight*

INTRODUCTION

The organism is subjected to a natural synchronized biological rhythm on the cycle of a 24 hour day. Better known as the circadian cycle. It regulates most of our biological and behavioural functions (Boivin, 2013). With aging, it can undergo some changes. Chen *et al*. (2016) witnessed a specific phase shift between a morning chronotype falling asleep and early awakening one. This result is due to a change in the rhythmicity of circulating hormones, cortisol, wakefulness hormone, and melatonin, the sleep hormone (Sack *et al*., 1992). This causes a disruption of the circadian synchronization system, desynchronization or decreased resynchronization rate, impacting the period, the amplitude and the regularity of the cycles.

Then, this disturbance then influences the quality of sleep and mood, but also can affect cognitive abilities during the day as demonstrated by Rouch *et al* (2005). The major element which generates and maintains this circadian cycle is the daily light-dark cycle (Wever, 1989). Indeed, light provides a fundamental signal which will rhythmize the cycles of sleep and wakefulness. But this circadian chronometry undergoes a reduction of its activity with the aging, especially the one with with visual pathologies. Indeed, Daneault *et al*. (2014) have shown that pathologies such as senile miosis or cataract reduce the quality and quantity of light received, reducing its beneficial impact on brain activity. But according to Campbell *et al*. (1993) and Holmes *et al*. (1994), a major vector compensates for this evolution, the light. Their studies showed that controlling exposure leads to significant changes in sleep quality, sleep / wake phase regulation, and mood. But the quantity of light isn't the only beneficial factor, the colour temperature also plays a major role (Rea *et al*., 2010). Indeed, exposure to different colour temperatures, between blue and yellow radiation, can partly controls the secretion and the absence of melatonin and cortisol (Gronfier, 2014), hormones generating the alternation between phases of sleep and waking.

With the advent of LED lighting systems and their potential use, a new lighting system is emerging, biodynamic lighting or Human Centric Lighting. This lighting system, based on comfort and needs of the user, aims to reproduce natural light, including modulating combined light intensity and colour temperature. The results proposed by Pohl *et al*. (2017) thus show a natural regulation of the circadian cycle, leading to a higher quality of sleep, an improvement in mood, and more generally to a better quality of life. They show us that a biodynamic lighting solution can naturally regulate the circadian cycle. Then it's a matter of suggesting this lighting solution to the elderly, at home as well as in institutions. This solution will be in order to regulate the evolution of the circadian cycle inherent to the age, avoiding recourse to a medicinal treatment.

EXPERIMENTATION

To measure this ability of such lighting to reproduce the natural light, and more precisely its spectrum, and thus its chromatic cycle, we took our interest in the domestic dynamic lighting solution offered by the Philips brand, Hue White ambiance. With a spectroradiometer we have been able to characterize the multiple possibilities of lighting. The multiple colour temperatures have been measured for different levels of luminance, dimmable by remote control or Smartphone application.

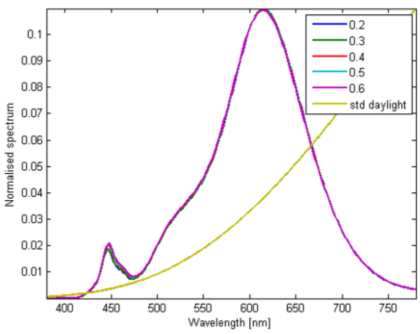
This made it possible to identify the spectra corresponding to each of them and to establish their radiometric and photometric conformity. The radiometric index was computed as the dot product of the normalized spectra over the range 380-780 nm. The photometric index is defined as the dot product of the normalized vectors obtained as the observed spectra weighted by the CIE1931 V(lambda) sensitivity function.

RESULTS AND DISCUSSION

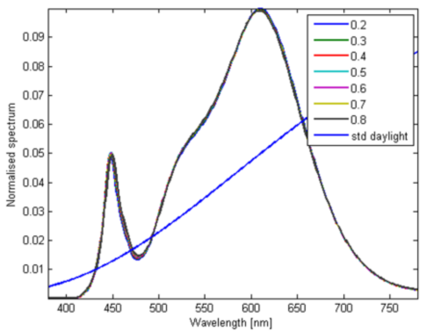
This dynamic lighting can produce four colours temperatures, on average 2244K corresponding to the light of a candle, 2900K corresponding to the sunrise or sunset, 4338K corresponding to the morning or afternoon sun, 6194K corresponding to a sun at zenith by clear sky (Condit and Grum, 1964, Judd *et al*., 1964, Taylor and Kerr, 1940), for a luminance ranging on average from 3800 cd·m-2 equivalent to the illumination of the morning or the evening, to 35000 cd·m-2 equivalent to the illumination of a clear sky at noon. An application for a dedicated Smartphone makes possible to configure predefined or customized cycles. Those cycles will be depending on our activities or the time slot of the day in order to create light sequences which aim to reproduce the natural light cycle.

Figure 1 shows the spectra of this lamp for each of the colour temperature, from 2244K to 6194K in order to respectively compare them with the spectra of daylight. The Tc1 spectrum doesn't share the same number of results due to inconsistencies in the obtained results. These spectra allow us to observe an increasing concordance at 500 nm, the optimum point of sensitivity of the human eye (Legrand, 1972), between the spectrum of natural light and the spectrum of the lamp, as its colour temperature increases. More generally, despite their resemblance despite the significant peaks in the blue radiation inherent in the LED system.

Spectrum Tc1



Spectrum Tc2



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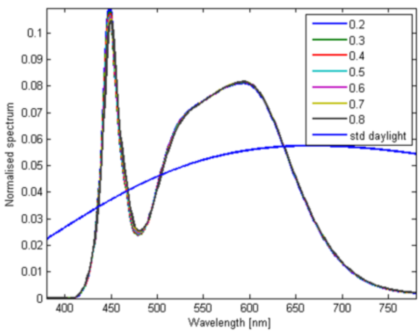


Spectrum Tc4

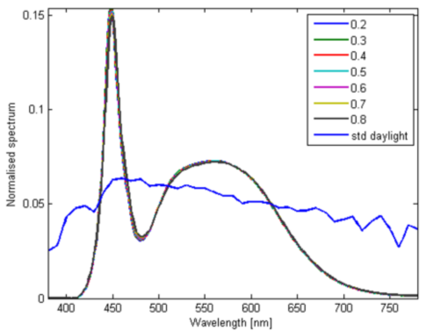


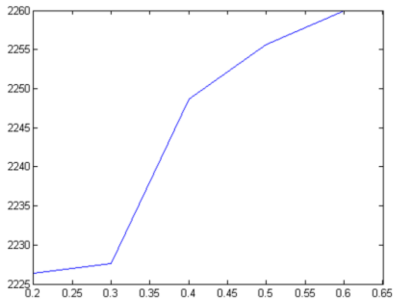
Figure 1 : Spectral distributions.

We can notice this resemblance in Table 1 between spectra of artificial lighting and daylight. Here you can see a remarkable level of photometric compliance here, while their radiometric conformity is increasing in the same time that the colour temperature. Regarding the colour temperatures, we note that they differ on average 200K compared to those announced by the manufacturer. We can also observe an evolution for each of them corresponding to the luminance changes.

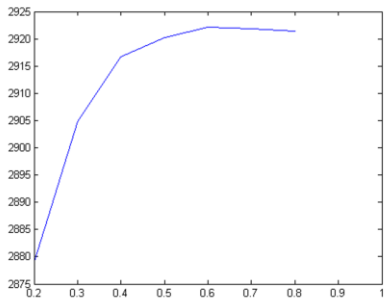
	Conformity spectral radiometric	**Conformity spectral Photometric**	**Average colour temperatures**	**Colour temperature variation**
Tc1	54%	99,3%	2244K	2227K – 2260K
Tc2	69%	99,6%	2900K	2880K – 2920K
Tc3	80%	99,6%	4338K	4320K – 4357K
Tc4	83%	99,4%	6194K	6184K – 6203K

Table 1 : Characteristics of colour temperatures.

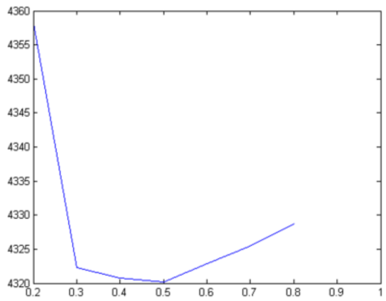
Variation Tc1



Variation Tc2



Variation Tc3



Variation Tc4

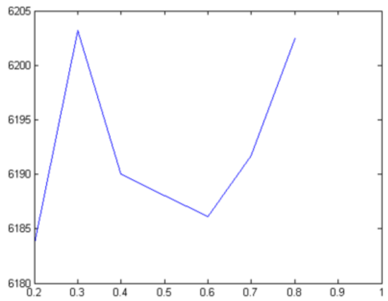
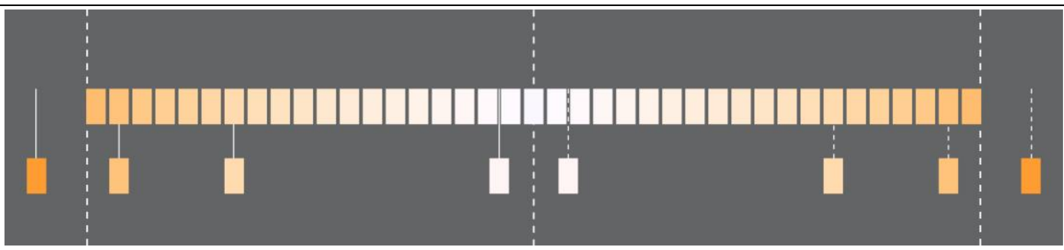


Figure 2 : Colour temperature variation.



2700K	6500K	2700K
Morning	Afternoon	

Figure 3 : Representation of the daily natural chromatic cycle VS artificial lighting.

Nevertheless, we can see with Figure 3 that those variations are generated by stages. Therefore they mostly remain imperceptible to the human eye which has a discriminating threshold greater than 5K (Legrand, 1972).

Despite a notable but negligible difference between radiometric and photometric conformance, it can be said that the proposed colour temperatures are similar to those of natural light (Condit and Grum, 1964, Judd *et al*., 1964, Taylor and Kerr, 1940), with a higher concordance for higher colour temperatures, which may suggest the chromatic cycle of natural light. However, this lighting doesn't allow us to reproduce it like the original. As a matter of fact the small choice for only four colour temperatures make almost impossible to retranscribe the chromatic richness of the daylight colour temperatures as shown in figure 4. But at least, it makes possible the comparison between the colour temperatures of the daylight and those produced by artificial lighting. We observe the reduced number of possibilities offered by the artificial lighting and also a lack of shades in the blue in favour of a yellow concentration. It is also noted that the lowest colour temperature produced by the lamp is deviating from normalized colour temperatures, confirming the inability of identical reproduction. It's the same case for spectra. Indeed, here it's impossible to reproduce the natural light spectrum, especially at low colour temperatures because of this peak in the 450nm blue. Which is a characteristic of LED technology, despite the levels in the green and yellow of 500nm to 650nm similar to those of natural light?

CONCLUSION

This home lighting solution now offers some possibilities of owning and modulating lighting. This is made possible by the various combinations possible between colour temperature and luminance degree. Despite announced colour temperatures different from those obtained. In addition, it doesn't yet reproduce the natural light cycle due to the limited number of colour temperatures and its characteristic spectrum of LED lighting, and doesn't cover the colour field of daylight.

However, this device offers opportunities for a complementary use of natural lighting, differentiating from traditional lighting. As a result, it makes possible to partially compensate the evolution of the circadian cycle of the elderly and at the same time to offer a higher comfort of life thanks to the artificial lighting and its multiple chromatic combinations.

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A Study on Afterimage Evaluation consequent on Changes in Lighting Area and Illumination Presentation

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ABSTRACT

Modern lighting has become available for system design, so is it available for multi-dimensional lighting other than one-dimensional lighting. By this, composition of lighting rays in line with a human's complex behaviour without setting them uniformly.

The method of changes in behaviour-starting-point lighting creation comes to have an unequal luminance ratio, and the unequal luminance ratio causes a very high feeling of fatigue on a human's visual-perceptual elements. The afterimage among the elements, which make it possible to identify a human's luminous ability, is the phenomenon, in which visual action remains even after the light stimulus is removed, and this study judges that it might be possible to identify an excited state of an eye caused by a light stimulus. Hereupon, this study identified the degree of an afterimage consequent on existence, or non-existence of dynamic changes (changes in area and space illuminance) of lighting in lighting environment available for lighting creation changes, and intended to organize the index for controlling an afterimage. The evaluation results are as follows:

1) An afterimage in time of creation constancy, appeared the most noticeably in low area & high illuminance, and the higher the illuminance, the more it increased. Accordingly, the solution to an ideal design plan is the one for the large area& low illuminance, which should be fulfilled with less than 150lx for both 900 x 900 (㎜) and 900 x 2100 (㎜). 2) The afterimage in time of lighting creation changes was found to be much influenced by 300 x 300 (㎜) 150 lx in following creation, which belongs to the scope of 'an unpleasant afterimage' in changes of small area & high illuminance in following creation, and thus attention is required in its use.

Keywords: *System Lighting, Presentation Change, Evaluation index, Afterimage, Lighting design, Light stimulus*

BACKGROUND AND PURPOSE OF STUDY

Illumination can be designed by system in modern times and multidimensional lighting, instead of one-dimensional lighting, can be used so that the light of illumination is not set uniformly but composed in accordance with the complex actions of man. At this time, the method of lighting design changes drastically among designs and has unequal luminance ratio. Unequal luminance ratio causes much feeling of fatigue to the visual-perceptual elements of man and decreases the visual capacity of man.

In this regard, this study examined the degree of afterimage according to the existence and nonexistence of dynamic changes of lighting (in area and spacial illumination) in a lighting environment in which lighting design can be changed, and presented the criteria for control of afterimage.

EXPERIMENT ENVIRONMENT

1) Experiment spaces

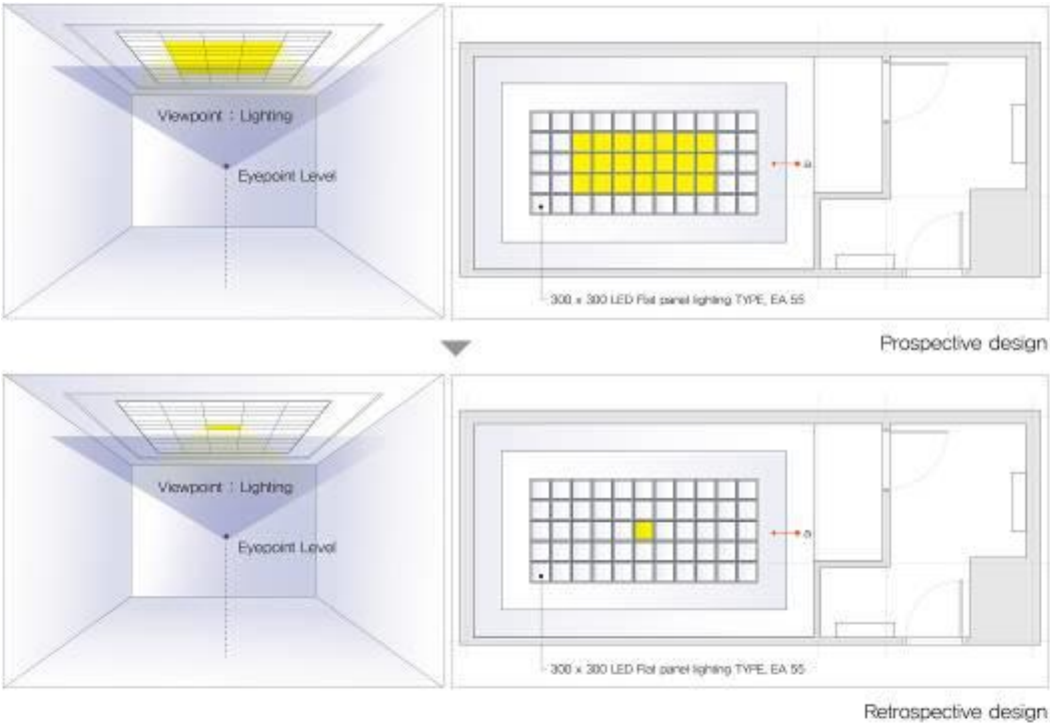
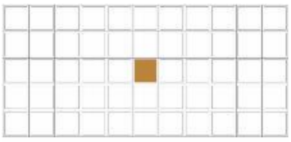
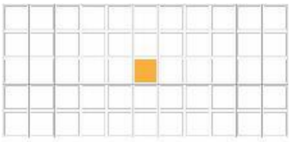
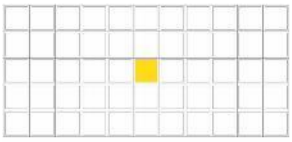
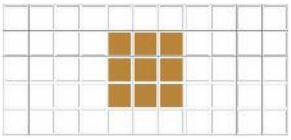
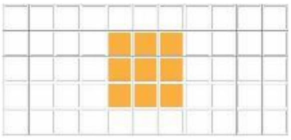
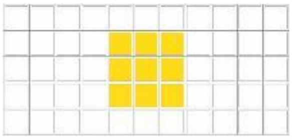
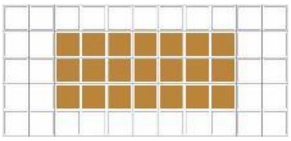
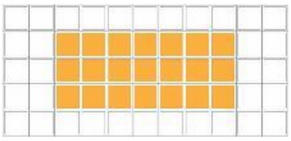
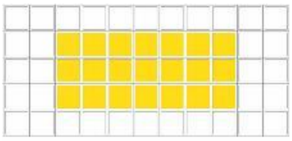


Figure 1: Examples of changes in experiment environment and design.

The experiment space was a darkroom of 3250 x 5080 x 2700 (mm). The lighting environment was created by large area lighting made of 55 grids (1 EA: 300 x 300 (mm)), and the furniture and colours that can affect visual evaluation were avoided. Among the characteristics of the change in lighting design, the light source at the time of no change in design maintains the same luminance after turning on light, and the lighting at the time of change in design changes from prospective design to retrospective design.

2) Variables of lighting

The variables of lighting are 300 x 300 (mm), 900 x 900 (mm) and 900 x 2100 (mm) in area and 10 lx, 50 lx and 150 lx of illumination. The average illumination of the space was measured by KS 5-point method using high-precision illuminometer (T10, Minolta) at the height of 80±5 cm from the floor.

 300 x 300 (mm)_ 10 lx				 300 x 300 (mm)_ 50 lx				 300 x 300 (mm)_ 150 lx			
a	73.7	b	0.2	c	4.4	a	385.5	b	0.9	c	23.2	a	1184.7	b	2.8	c	70
 900 x 900 (mm)_ 10 lx				 900 x 900 (mm)_ 50 lx				 900 x 900 (mm)_ 150 lx			
1	5.46	b	0.1	c	1	a	45.1	b	1	c	7.8	a	133.4	b	2.8	c	23.3
 900 x 2100 (mm)_ 10 lx				 900 x 2100 (mm)_ 50 lx				 900 x 2100 (mm)_ 150 lx			
a	5.8	b	0.3	c	1.6	a	19.2	b	0.9	c	5.1	a	57.8	b	3	c	15.7

a. Luminance of light source, b. Luminance of background, c. Standard deviation

Table 1: Variables of lighting designs and amount of luminance.

PARTICIPANTS IN EXPERIMENT

The characteristics of the subjects of experiment who participated in the evaluation of feeling of fatigue according to the characteristics of lighting design are shown in Table 2. A total of 18 students composed of juniors and seniors in the department of architectural engineering as well as graduate students who have no ophthalmologic disease including colour weakness and colour blindness with over 1.0 of corrected eyesight and considered to have perceptual abilities in the environment of architectural lighting were selected to participate in the experiment.

EVALUATION METHOD

The subjects are positioned in Figure 1_a at the time of evaluation and perceived the lighting environment by changing the viewpoints 4 times in total.

Regarding the viewpoints of the subjects when design was changed; they looked at the front side by the command of 'One' of the supervisor of the evaluation, the light source of the design by the command of 'Two', the changed light source of the design by the command of 'Three' and then again the front side at the command of 'Four' to examine the degree of afterimage created by the change of design.

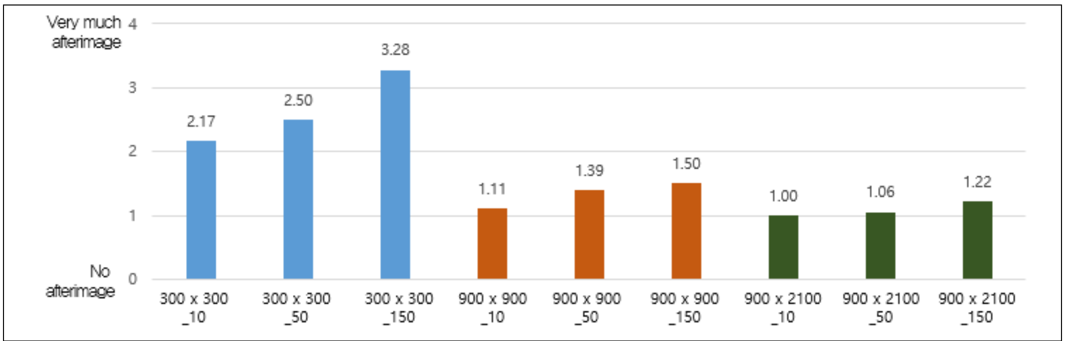
The questionnaires were evaluated through subjective scales, and the scale and degree of the evaluation are as follows. The afterimage was scaled by 5 points on both sides with no afterimage (0) and very much afterimage (5) at the ends. The less the point, the more positive index. The degree of 'no afterimage' was classified as A; the degree of 'beginning to have afterimage' as B, the degree of 'bothersome afterimage' as C; and the degree of 'very much afterimage' as D.

EVALUATION RESULTS

1) With no change in design

The afterimage when the design is not changed is the most ideal if it is included in less than 1 of the permissible range, and the starting point of the afterimage was confirmed. According to the evaluation results, it was the highest with small area and high illumination and the afterimage increased with the increase of illumination.

The scope of 'beginning to have afterimage (B)' was 900 x 900 (mm) and 900 x 2100 (mm) of area both of which were below 150 lx. The scope of 'very much afterimage (D)' was over 150 lx in 300 x 300 (mm) of area.



	300 x 300 _10	300 x 300 _50	300 x 300 _150	900 x 900 _10	900 x 900 _50	900 x 900 _150	900 x 2100 _10	900 x 2100 _50	900 x 2100 _150
Avg.	2.17	2.5	3.28	1.11	1.39	1.5	1	1.06	1.22

beginning to have afterimage (B), bothersome afterimage (C), very much afterimage (D)

Table 1: Results of evaluation of afterimage (With no change in design).

2) With change in design

The afterimage when the design is changed is the most ideal if it is included in less than 1 of the permissible range, and the starting point of the afterimage was confirmed. In general, the retrospective design of 300 x 300 (mm) 150 lx had much influence. The design which had the most change in afterimage in the evaluation was when the prospective design of 900 x 2100 (㎜)_10 lx changed to retrospective design of 300 x 300 (mm)_150 lx and it is the area of 'bothersome afterimage' that needs attention in use.

The following are the degree of afterimage changed in the retrospective design for each prospective design.

· The prospective design with 300 x 300 (mm)_10 lx was included in the range of 'no afterimage' in the same change of illumination except the same scope of design.

· The prospective design with 900 x 900 (mm)_10 lx was included in the range of 'no afterimage' in the same change of illumination of 900 x 2100 (mm)_10 lx.

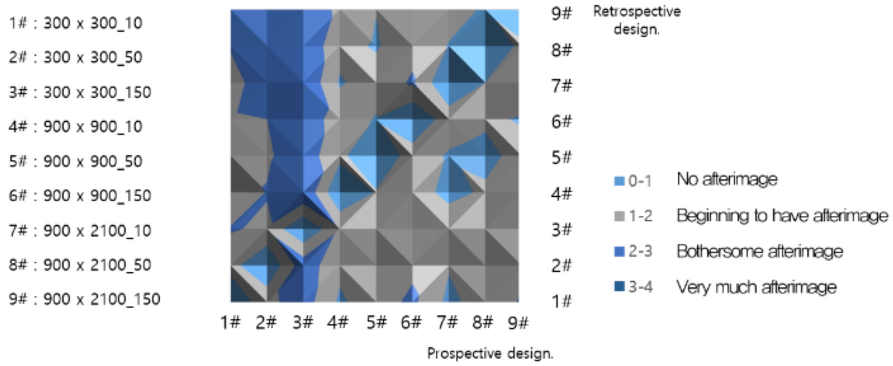
· The prospective design with 900 x 900 (mm)_50 lx was included in the range of 'no afterimage' in the change of area 900 x 2100 (mm)_10 lx and 50 lx.

· The prospective design with 900 x 900 (mm)_150 lx was included in the range of 'no afterimage' in the change of area 900 x 900 (mm)_50 lx and 900 x 2100 (mm)_150 lx.

· The prospective design with 900 x 2100 (mm)_10 lx was included in the range of 'no afterimage' in the same change of illumination of 900 x 900 (mm)_10 lx.

· The prospective design with 900 x 2100 (mm)_50 lx was included in the range of 'no afterimage' in the change of 900 x 900 (mm)_50 lx and 900 x 2100 (mm)_10 lx.

· The prospective design with 900 x 2100 (mm)_150 lx was included in the range of 'no afterimage' in the change of 900 x 900 (mm)_50 lx.



구분		Retrospective design.								
		300 x 300 _10	300 x 300 _50	300 x 300 _150	900 x 900 _10	900 x 900 _50	900 x 900 _150	900 x 2100 _10	900 x 2100 _50	900 x 2100 _150
Prospective design	300 x 300_10	-	1.74	2.5	0.84	1.53	2.21	0.76	1.45	2.08
	300 x 300_50	1.37	-	2.61	1.24	1.05	1.79	1.08	1.13	1.92
	300 x 300_150	2.08	1.84	-	1.89	1.45	1.58	2	1.5	1.53
	900 x 900_10	1.03	2.05	2.92	-	1.08	1.74	0.55	1.21	1.95
	900 x 900_50	1.68	1.87	2.55	1.26	-	1.53	0.89	0.61	1.47
	900 x 900_150	1.92	2	2.5	1.61	0.92	-	1.55	1.21	0.89
	900 x 2100_10	1.76	2.37	2.97	0.89	1.5	2.11	-	1	1.92
	900 x 2100_50	2.05	2.45	2.82	1.32	0.89	1.76	0.95	-	1.26
	900 x 2100_150	2.24	2.13	2.71	1.79	1.03	1.21	1.37	0.89	-

no afterimage (A), beginning to have afterimage (B), bothersome afterimage (C), very much afterimage (D)

Table 2: Results of evaluation of afterimage (With change in design).

CONCLUSIONS

This study confirmed the degree of afterimage according to the existence and nonexistence of dynamic changes of lighting (in area and spatial illumination) in a lighting environment in which lighting design can be changed, and the conclusions are as follows.

1) The afterimage when the design is not changed appeared the most in a small area with high illumination, and it increased as the illumination increased. An ideal design is to be made with a wider area and low illumination in 900 x 900 (mm) and 900 x 2100 (mm) of area both below 150 lx.

2) The afterimage when the design is not changed was affected much in retrospective design with 300 x 300 (mm)_150 lx. It is a range of 'bothersome afterimage' in the change of retrospective design with small area and high illumination and needs attention in use. An ideal design is changing the prospective design with 900 x 900 (mm)_50 lx to the retrospective design with 900 x 2100 (mm)_10 lx, and the use of the degree of 'beginning to have afterimage(B)' will have to be considered according to the characteristic of the design of the user.

ACKNOWLEDGEMENTS

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An approach to face contrasts in women faces under CIE standard illuminants and representative white LED sources

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ABSTRACT

From average measurements of spectral reflectance factors at 3 different regions of the body (forehead, cheek and neck) in a set of 87 women from two different ethnics (50 Caucasian and 37 Oriental), plus a set of 5 commercial red lipsticks, we computed several CIELAB colour differences ($\Delta E^*_{ab,10}$) under 18 light sources divided in two Groups: CIE standard illuminants A, D50, D55, D65, D75, FL2, FL7, and FL11 (Group 1); 10 white LEDs considered representative of those currently available in the market (Group 2). We analysed the magnitude and characteristics of $\Delta E^*_{ab,10}$: I) In only one region of the body (two ethnics); II) In two regions of the body (each ethnic); III) Cheeks-lipsticks (each ethnic). For cheeks-lipsticks, the standard deviations of $\Delta E^*_{ab,10}$ were consistently higher in Group 2 than in Group 1, in a factor up to 2.2. Some white LEDs, particularly RGB LEDs, achieved highest contrasts in women faces.

Keywords: *Colour difference, white LED, colour inconstancy, human skin, cosmetics.*

INTRODUCTION

´Facial contrast' has been defined as the luminance or colour difference between the facial features and the skin surrounding those features [Porcheron *et al.*, 2013]. Facial contrast is important because of its association with attractiveness, health and perceived age, mainly for women's faces [Fink *et al.*, 2006; Fink *et al.*, 2012; Matts *et al.*, 2007; Samson *et al.*, 2010]. Some papers on facial contrast focused on one dimension (e.g. lightness or luminance contrasts), but authors have reported the need of considering colour contrast (i.e. three dimensions) between facial features and surrounding skin, for related face-perception tasks and sex classification [Nestor *et al*., 2008; Dupuis-Roy *et al*., 2009].

On the other hand, previous papers reported on critical spectral components for the preferable appearance of the skin in women's faces [Okuda *et al*., 2016], or preferable LED lamps for the appearance of skin in daily lives [Jost-Boissard *et al*., 2016]. Our current approach to facial contrast in women's faces is just based on objective instrumental colour measurements, not subjective preference measurements of facial contrasts. Specifically, we propose the evaluation of facial contrasts using the total CIELAB colour difference ($\Delta E^*_{ab,10}$) and its three components: Lightness, chroma and hue differences [CIE, 2004]. While CIEDE2000 is the current colour-difference formula jointly recommended by CIE and ISO [CIE, 2013], in this paper we have decided to use the CIELAB colour-difference formula because several reference conditions in CIEDE2000 are not appropriate in our viewing situation (e.g. illuminant D65, samples without separation, $\Delta E^*_{ab,10}<5$).

MATERIAL AND METHODS

Spectrophotometric measurements of skin (400-700 nm, steps of 10 nm) were carried at three different places of the body (cheek, forehead and neck) for a set of 87 healthy young women (20-35 years old) from two different ethnics groups (50 Caucasian and 37 Orientals). Specifically, we used a CM-700d (Konica Minolta) spectrophotometer with 8 mm aperture, and a plate fitting the aperture window with low pressure on subject's body [Want *et al*., 2015]. Additionally, a CM-2600d (Konica Minolta) spectrophotometer was employed to measure the spectral reflectance factors (400-700 nm, steps of 10 nm) of 5 representative lipsticks of the company Chanel, with commercial names Louise, Coco, Olga, Gabrielle and Erik [Melgosa *et al*., 2018].

We computed CIELAB colour coordinates for each one of these objects, assuming the CIE 1964 standard colorimetric observer [CIE, 2004], using 18 different light sources distributed in two Groups: CIE standard illuminants A, D50, D55, D65, D75, FL2, FL7, and FL11 (Group 1); 10 white LEDs considered representative of those currently available in the market (Group 2). Light sources in Group 1 are traditional CIE illuminants, including main indoor (A) and outdoor (D65) lights, daylights with usual correlated colour temperatures (D50, D55 and D75), and main CIE fluorescent illuminants (FL2, FL7 and FL11). Light sources in Group 2 are modern white LED sources using different technologies [Jost *et al*., 2017; Melgosa *et al*., 2018]. The spectral power distributions of all these 18 light sources were normalized to Y=100 for a sample with spectral reflectance factor equal to 1.0 at all wavelengths. Our main goal is to report on changes in facial contrasts of women, produced by the use of sources in Group 2 in comparison with those in Group 1.

RESULTS AND DISCUSSION

Table 1 shows average CIELAB colour differences ($\Delta E^*_{ab,10}$) in the skin of women from two ethnics, considering three parts of the body (cheek, forehead and neck) and light sources in Group 1 (G1) and Group (2). The values in column 2 of Table 1 are not at all negligible, indicating relevant colour differences between both ethnics. However, here we mainly focus on the last two columns in Table 2, showing colour variability (standard deviation and coefficient of variation) produced by the use of the lighting sources in G1 and G2. As we can see, this variability is very small, because the highest standard deviation is 0.2 CIELAB units, and higher in G2 than in G1 for forehead and neck (not for cheek).

Element	Average $\Delta E^*_{ab,10}$	St. Deviation	Coefficient of Variation
Cheek G1	3.29	0.20	6.1%
Cheek G2	3.34	0.13	4.0%
Forehead G1	6.61	0.05	0.7%
Forehead G2	6.65	0.09	1.4%
Neck G1	7.36	0.03	0.4%
Neck G2	7.40	0.09	1.2%

Table 1: CIELAB colour differences for women from Oriental and Caucasian ethnics, considering three parts of the body (cheek, forehead and neck) under light sources in Groups 1 and 2 (see text).

Elements	Average $\Delta E^*_{ab,10}$	St. Deviation	Coefficient of Variation
Cheek-Forehead Oriental G1	4.91	0.09	1.8%
Cheek-Forehead Oriental G2	4.91	0.09	1.9%
Cheek-Forehead Caucasian G1	2.76	0.24	8.8%
Cheek-Forehead Caucasian G2	2.70	0.14	5.0%
Cheek-Neck Oriental G1	5.61	0.52	9.2%
Cheek-Neck Oriental G2	5.25	0.43	8.1%
Cheek-Neck Caucasian G1	7.61	0.41	5.4%
Cheek-Neck Caucasian G2	7.59	0.83	10.9%
Forehead-Neck Oriental G1	4.26	0.13	3.0%
Forehead-Neck Oriental G2	4.15	0.33	7.9%
Forehead-Neck Caucasian G1	5.27	0.23	4.5%
Forehead-Neck Caucasian G2	5.32	0.79	14.9%

Table 2: CIELAB colour differences between two parts of the body of women, considering the Oriental and Caucasian ethnics, under light sources in Groups 1 and 2 (see text).

Table 2 shows analogous information to the one in Table 1, but now considering colour differences between two parts of the body. In Table 2 we focus again in the last two columns, indicating colour variability produced by light sources in G1 and G2, which is small, but higher than the one in Table 1 (e.g. standard deviations up to 0.79 CIELAB units). Finally, Table 3 shows analogous information to the one in Tables 1 and 2, but considering CIELAB colour differences between cheeks (Oriental and Caucasian women) and five commercial lipsticks, under light sources in G1 and G2. It is noticeable that, as expected, in most cases the average colour differences and standard deviations (columns 2 and 3) in Table 3 are considerably higher than those in previous Tables 1 and 2. However, the most relevant result in Table 3 is that standard deviations and coefficients of variation (last two columns) are always higher in G2 than in G1, in a factor up to 2.2, and with relatively high coefficients of variation, up to 21.5% (see row Louise-Cheek Oriental, G2).

Elements	Average $\Delta E^{*}_{ab,10}$	St. Deviation	Coefficient of Variation
Louise-Cheek Oriental G1	9.92	1.22	12.3%
Louise-Cheek Oriental G2	10.31	2.22	21.5%
Louise-Cheek Caucasian G1	9.65	1.12	11.6%
Louise-Cheek Caucasian G2	10.21	1.58	15.5%
Coco-Cheek Oriental G1	42.93	3.20	7.5%
Coco-Cheek Oriental G2	44.35	6.98	15.7%
Coco-Cheek Caucasian G1	42.75	3.10	7.2%
Coco-Cheek Caucasian G2	44.19	6.48	14.7%
Olga-Cheek Oriental G1	31.69	3.32	10.5%
Olga-Cheek Oriental G2	29.31	4.77	16.3%
Olga-Cheek Caucasian G1	29.22	3.36	11.5%
Olga-Cheek Caucasian G2	26.83	4.61	17.2%
Gabrielle-Cheek Oriental G1	35.72	2.06	5.8%
Gabrielle-Cheek Oriental G2	35.47	3.97	11.2%
Gabrielle-Cheek Caucasian G1	35.48	2.11	5.9%
Gabrielle-Cheek Caucasian G2	35.30	3.68	10.4%
Erik-Cheek Oriental G1	37.91	0.78	2.1%
Erik-Cheek Oriental G2	37.76	0.85	2.2%
Erik-Cheek Caucasian G1	37.58	0.59	1.6%
Erik-Cheek Caucasian G2	37.77	0.67	1.8%

Table 3: CIELAB colour differences between 5 commercial lipsticks (Louise, Coco, Olga, Gabrielle, and Erik) and cheeks of Oriental and Caucasian women, under light sources in Groups 1 and 2 (see text).

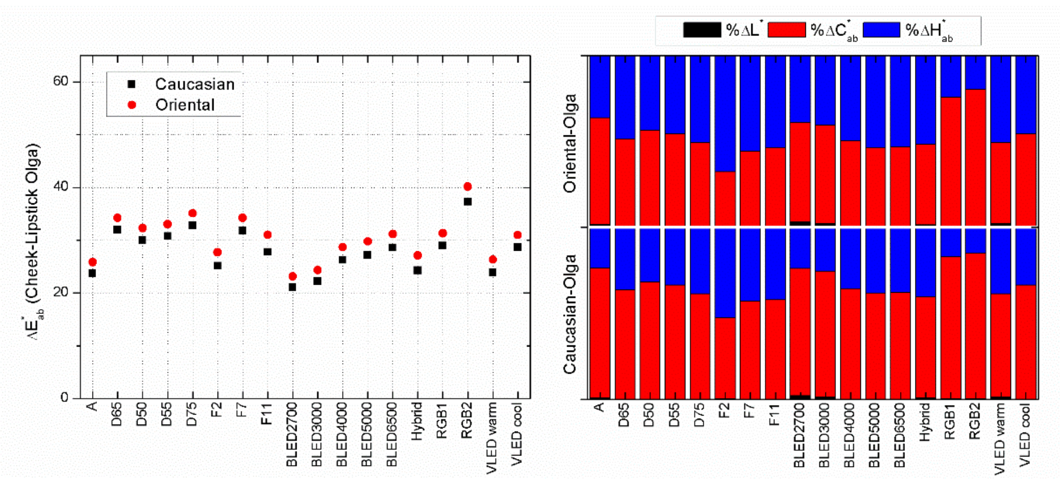

Figure 1: CIELAB colour differences (left) and its three components in percentage (right), considering cheek (both Caucasian and Oriental women) and lipstick Olga, under each of the 18 light sources.

As an example, Figure 1 shows CIELAB colour differences (left) and their three components (right) for cheeks and lipstick Olga, considering each of the 18 light sources tested. The results for cheeks in Caucasian and Oriental women are enough similar in Figure 1. However, the variability in G2 is higher than in G1 (see Figure 1, left), with values around 40 and 20 CIELAB units for white LEDs named RGB2 and BLED2700, respectively. We can also note that the percentages of chroma differences in total colour differences are particularly high for the white LEDs named RGB1 and RGB2 (see red bars in Figure 1, right). This means that visual contrasts between cheeks and lipstick Olga will be different under these two white LEDs than under the remaining light sources.

CONCLUSION

We used CIELAB colour differences and their components as an objective approach to measure women's facial contrasts [Melgosa *et al*., 2018]. Variability in facial contrast with light sources was very small (<0.2 CIELAB units standard deviation) considering only one part of the body in two different ethnics, and small (<0.8 CIELAB units standard) considering two parts of the body in any of the two ethnics. However, for cheek-lipsticks, colour differences (i.e. facial contrasts) were relevant and consistently higher under light sources in Group 2 (white LEDs) than under light sources in Group 1 (traditional CIE illuminants) in a factor up to 2.2. Some white LEDs, particularly RGB LEDs, achieved highest facial contrasts.

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Effects of Light Colour on Appearance of Interior Material and Preference of Lighting

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ABSTRACT

This study aims to clarify the preferable lighting conditions for the appearance of the interior material. We conducted a subjective experiment using four types of the scale models, "Simple", "Natural", "Traditional" and "Japanese" rooms. Twelve kinds of lighting conditions were set using five LED lamps above mentioned. Participants evaluated the naturalness of colour appearance of walls and floor and the impression of the room. According to the results, In conclusion, the lighting in 3000-4000K and negative *duv* is preferred in "Simple" room, "Traditional" room and "Natural" room, whereas the lighting in 5000K and *duv*=0 is preferred in "Japanese" room. Therefore, the preferred lighting colour depends on the interior material of room.

Keywords: *Light colour, Naturalness of colour appearance, Interior material, Preference*

INTRODUCTION

A room is composed of some interior elements, walls, floors, ceilings and other furniture. Among them, walls and floor greatly affect the impression, occupying a large area in a room. The material of walls and floors of houses and shops are diversified and the impression of the room is determined by the colour and texture of interior materials. Lighting is also one of the factors determining the impression of a room. Recently, LED lighting has become very popular, hence various kinds of light colour have been designed according to the intended purpose or the atmosphere of a room. Also, the colour appearance of the objects in a room depends on the light colour.

The previous study indicated that the light itself was the most crucial factor for predicting the preferred lighting (Huang, 2017). It was also reported that the interior material in cold hue was preferred in cold light, while that in warm hue was preferred in warm light (Schüpbach, 2015). In the research of Maki (2009), the rooms with the interior material in R hue were preferable and comfortable under warm light, whereas those in cold hue were harmonious and beautiful under cold light.

From the above background, this study aims to clarify the preferable lighting conditions for the appearance of the interior material.

EXPERIMENTAL

First, we made four types of 1/10 scale model of rooms, "Simple", "Natural", "Traditional" and "Japanese". Figure 1 shows the photos of four types of rooms. "Simple" room was composed of walls with white wallpaper (vinyl cloth) and wooden floor. "Natural" room was composed of wooden walls and wooden floor. "Traditional" room consisted of brick walls and wooden floor. "Japanese" room was composed of walls with wallpaper (vinyl cloth like sand-wall) and tatami-floor. Each scale model equips two RGB LED lamps and three white LED lamps which could control correlated colour temperature. Next, twelve kinds of lighting conditions were set with four levels of CCT (3300K, 4000K, 5000K, 6700K) and three kinds of *duv* (-0.01, 0, +0.01) in each CCT condition, using five LED lamps above mentioned. Table 1 shows twelve kinds of lighting conditions.

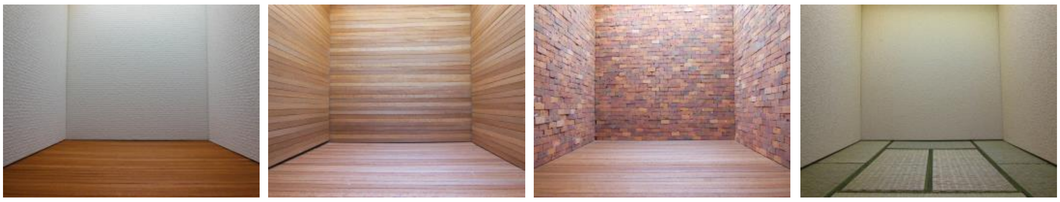

Figure 1: Four types of 1/10 scale model of rooms.

Table 1: Lighting conditions.

Condision	CCT (K)	*duv*	*u'*	*v'*	*Ra*
3300K-10	3300	-0.010	0.245	0.501	87
3300K	3300	0.000	0.241	0.516	83
3300K+10	3300	+0.010	0.237	0.529	85
4000K-10	4000	-0.010	0.231	0.490	84
4000K	4000	0.000	0.225	0.501	82
4000K+10	4000	+0.010	0.220	0.514	86
5000K-10	5000	-0.010	0.218	0.474	86
5000K	5000	0.000	0.211	0.485	82
5000K+10	5000	+0.010	0.205	0.495	82
6700K-10	6700	-0.010	0.208	0.454	84
6700K	6700	0.000	0.200	0.463	81
6700K+10	6700	+0.010	0.192	0.472	82

Participants observed each type of room model under twelve lighting conditions and evaluated the naturalness of colour appearance of walls and floor with a numerical scale from 0 (very unnatural) to 6 (very natural). Additionally, they answered the impression of the room using semantic differential method with eighteen pairs of adjective in a seven-steps scale, and also rated the preference of lighting with a numerical scale from -3 (not prefer) to +3 (prefer). Twenty female university students participated in this experiment voluntarily, and they were in all twenties and normal colour vision.

RESULTS AND DISCUSSION

Figure 2 shows the evaluations results of naturalness of colour appearance of walls in all types of rooms. As the results of the naturalness of colour appearance, the evaluation of white wall in “Simple” room was good under 5000K in *duv*=0, and *duv*=-0.01, and 4000K in *duv*=-0.01. Also, the evaluation of wooden walls and wooden floor in “Natural” room was good under 3000K in *duv*=-0.01, 4000K in *duv*=-0.01 and 4000K in *duv*=0, and that of brick walls in “Traditional” room was good under 3000K in *duv*=-0.01, 4000K in *duv*=-0.01. The evaluation of sand-wall and tatami-floor in “Japanese” room was good under 5000K in *duv*=0, but was bad under 3000K in *duv*=+0.01.

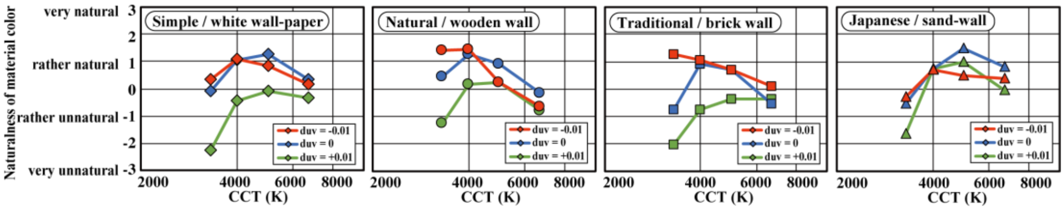

Figure 2: Evaluation results of naturalness of colour appearance of walls in all types of rooms.

Figure 3 illustrates the factor scores acquired from the results of the factor analysis, using data of the impression evaluation. It was shown taht “Potency” and “Evaluation” were extracted. It was cleared that “Potency” in the rooms under the lighting in low *CCT* (3300K and 4000K) was high, and that “Evaluation” in the rooms under the lighting in low *duv* (-0.01 and 0) was high.

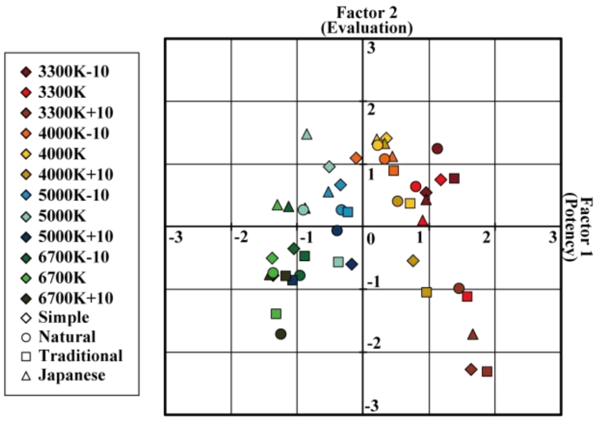

Figure 3: Factor scores of the results of factor analysis on the impression evaluations.

Figure 4 shows the evaluations results of preference of lighting in all types of rooms. As the results of the preference of lighting, “Simple” room and “Traditional” room were most preferred under 4000K in *duv*=0 and *duv*=-0.01, and “Natural” room was highly evaluated under 3000K and 4000K in *duv*=0 and *duv*=-0.01. However, “Japanese” room was preferred under 4000K and 5000K in *duv*=0.

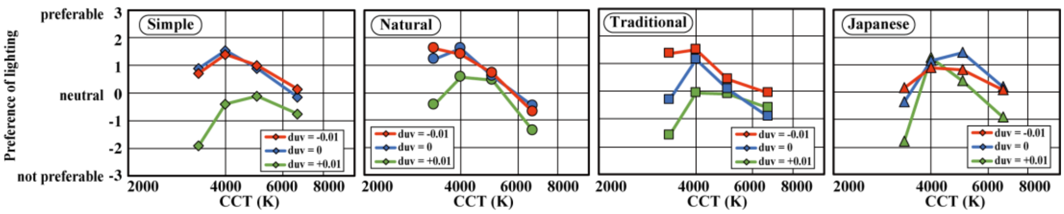

Figure 4: Evaluation results of preference of lighting in all types of rooms.

CONCLUSION

In conclusion, the lighting in 3000-4000K and negative *duv* is preferred in “Simple” room, “Traditional” room and “Natural” room, whereas the lighting in 5000K and *duv*=0 is preferred in “Japanese” room. Therefore, the preferred lighting colour depends on the interior material of room.

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colour & human comfort

A Study on a Senior Citizen's Discrimination of Colour Perception consequent on Colour Temperature & Illuminance of LED Lighting, Character Size, Ground Colour and Character Colour - On the basis of Visibility Range of 2m

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ABSTRACT

This study intended to look into the colour perception discrimination in the elderly's vision of similar colours. This study proceeded with experiments on the four sorts of basic colours of NCS of colour specification, i.e. red, yellow, green, blue by putting a difference in black colour degree, pure colour degree, black pure colour degree and colour mixture proportion. At this moment, this study also looked into whether there existed a difference in colour perception discrimination depending on the colour temperature, and illuminance of LED lighting, and text size. The results showed that it's possible for the elderly to perceive a colour and a text when a text size was more than 0.7cm×0.75cm, and black colour content showed a more than 10% difference, respectively, and when illuminance was more than 100lx. In contrast, in case of a difference between the pure colour degree, the black pure colour degree and colour, the elderly people showed a different result according to a text size. Also, There was no difference consequent on colour temperature. It is thought that the influence by brightness is bigger than the one by colour temperature.

Keywords: *Elderly, LED lighting, Illuminance, Text Size, Colour*

INTRODUCTION

The function of the sensory organ is aging along with the increase in age, and the change of one's vision which accounts for more than 80% of the information acquisition, or due to aging eyes & eye diseases in senescence, a senior citizen experience many hardships in doing usual activities. Particularly, it is difficult to classify similar colours according to yellowing of the eye lens, and the decrease in colour sense, so a senior citizen feels displeasure, or could experience inconvenience due to the failure to perceive important information.

Moreover, senior citizens are in a physically malfunction state, so they could come near incurring danger in the aspect of safety. From this perspective, consideration for a senior citizen's visual characteristics should be concretely applied at the time of colour environment planning. In addition, as LED light has developed and it is becoming widely available, together with the reduction in initial purchase cost of it, LED has been applied to not only public institutions but also commercial space as well as housing space. LED lighting is easy & free to adjust colour temperature and brightness, so diverse creations of LED lighting are available according to a user characteristic, or space atmosphere. Nevertheless, there might be a difference in the level of classification of similar colours in the case of a senior citizen according to the colour temperature, and space brightness variations of LED lighting. In addition, even according to the colour application area, or size, there might be a difference in the classification level of similar colours in the case of a senior citizen, and that's why consideration should be given to this.

Accordingly, this study intended to look into the colour perception discrimination in a senior citizen's vision of similar colours in the case of a short distance (basis of 2 meters). Then, this study conducted the experiment by putting a difference in blackness, chromaticness, pure blackness and colour mixing ratio in relation to the four sorts of base colours- red, yellow, green and blue of the Natural Colour System. At this moment, this study also looked into whether there existed a difference in colour perception discrimination according to colour temperature & illuminance of LED lighting, and character size.

EXPERIMENTAL METHOD

The experiment was conducted in the space(5.18m×4.31m×2.50m) consisting of a luminous ceiling. The lighting presented at the time of the experiment was 3,000K and 6,000K in colour temperature. In addition, the average illuminance was measured to be 100lx, 500lx, and 1,000lx by using the 9-point method at the height of 85±5cm from the bottom.

NCS Code	Blackness	Chromaticness	Pure Blackness	Colour mixing ratio (S-3040-colour)
S-*Number*-Y/R/B/G	S 1040-Y/R/B/G	S 3020-Y/R/B/G	S 5020-Y/R/B/G	G80Y, G90Y, Y, Y10R, Y20R
	S 2040-Y/R/B/G	S 3030-Y/R/B/G	S 4030-Y/R/B/G	Y80R, Y90R, R, R10B, R20B
	S 3040-Y/R/B/G	S 3040-Y/R/B/G	S 3040-Y/R/B/G	R80B, R90B, B, B10G, B20G
	S 4040-Y/R/B/G	S 3050-Y/R/B/G	S 2050-Y/R/B/G	B80G, B90G, G, G10Y, G20Y
	S 5040-Y/R/B/G	S 3060-Y/R/B/G	S 1060-Y/R/B/G	

Table 1: Outline of the Subject for Evaluation.

This study used the colours for evaluation with focus on 100% colours of the 4 sorts of base colours of the Natural Colour System - red, yellow, green and blue. Then, this study applied S3040 as the ground colour by each colour. In addition, this study applied the colours, which showed a difference of 10% and 20% respectively in blackness, chromaticness, pure blackness and colour mixing ratio, as character colours with S3040 as the centre. In addition, this study organized the character size with a total of 4 sorts (6cm×6cm, 3cm×3cm, 1.5cm×1.5cm, 0.75cm×0.75cm in length and breath, respectively), and Arabic numerals (2,3,4,5,6,9). For the ground colour and numeral colour, this study did colour-mixing work at Adobe Illustrator CS5.1. For correction of colours by output, this study corrected the colour difference(△E*ab) from the coloured paper actually produced by the Natural Colour System into △E*ab ≤ 5 on the basis of CIE Lab after doing colorimetry of the output using the spectrum colorimeter (Minolta, CM-700d). The details of the produced subject for evaluation are as in the following <Table 1>.

Figure 1: Example of the Subject for Evaluation.

This study presented the evaluation subject in contrast to the ground colour and character colour, which were produced like this, on a wall of the experimental space. Then, this study got the experiment participants to say the numbers indicated by an examiner with perception after adapting themselves to the given lighting environment at a position 2 meters away from the evaluation subject for more than 1 minute. At this moment, the examiner filled the experimental results of individual participants in the evaluation sheet. The examiner entered 2 points for the case where a participant said a number in less than 3 seconds through the momentary perception, 1 point for the case where a participant said a number between more than 3 seconds & less than 10 seconds, and 0 point for the case a participant made an incorrect answer, or replied 'No idea as to what number.' The scene of doing experiment is as <Fig. 2>.

This study organized the experiment participants with 20 general adults in their 20s~30s, and 20 senior citizens aged above 65.

Figure 2: Example of the Scenes of Doing Experiment.

RESULTS AND DISCUSSION

In the case of the difference in blackness, it was found that the general adults in their 20s~30s could read numerals under all conditions when the range of sight was 2 meters. In other words, in the case where a character size is more than 0.75cm×0.75cm; a difference in the mixing rate of blackness is more than 10%, and illuminance is more than 100lx, legibility is extremely good by dint of the ability to recognize characters momentarily. Even in the case of the senior citizens aged above 65, their legibility consequent on the difference in blackness is far better in comparison with the difference in chromaticness, pure blackness, and colour mixing ratio. Nevertheless, it is thought that the character size of more than 1.5cm×1.5cm would be better from the aspect of information delivery, or safety securement. In case where small size characters are to be applied, the minimum difference in the blackness mixing ratio should be more than 20%, and illuminance should be more than 100lx, or a lot brighter illuminance application is desirable.

In case of a difference of 10% in chromaticness, the yellow character is well legible in size of more than 3cm×3cm while red and blue characters are well legible in more than 1.5cm×1.5cm size. In case where a character size is smaller than this, there follows a somewhat difficulty with momentary recognition. On the contrary, the legibility of Green is good down to the size of 0.75cm×0.75cm, so it's possible to apply the 10% difference in chromaticness even to tiny size characters. In addition, in case of the 20% difference in chromaticness, Red and Yellow are legible in character size of more than 1.5cm×1.5cm while Blue and Green are well legible in character size of more than 0.75cm×0.75cm. It's desirable to make a large difference in chromatic ness in the case of Red and Yellow comparing to Blue and Green, and to avoid the application of a small-size character and low illuminance.

In case where there is the 10% & 20% difference in pure blackness, the desirable character size of all colours is more than 1.5cm×1.5cm. In case where a character size is smaller than this, there might be a somewhat difficulty in momentarily recognizing it. Yellow and Green are somewhat higher in legibility consequent on the difference in pure blackness in comparison with other colours. Accordingly, when a character size is 0.75cm×0.75cm, legibility is very good exclusive of 100lx in 3000K.

In case of the 10% difference in the colour mixing ratio, the desirable character size of Red, Yellow and Blue is more than 6cm×6cm while the character size of more than 1.5cm×1.5cm in case of Green. In case there is the 20% difference in the colour mixing ratio, the desirable character size of Red, Yellow and Blue is more than 3cm×3cm while more than 1.5cm×1.5cm in character size is recommendable in case of Green. Much too small size characters are bad in legibility under all conditions of colour temperature and illuminance.

Difference	Colour	Application Standard		
		Font Size	Percentage gap	Illuminance
Blackness	R,G,B,Y	More than 0.75cm×0.75cm	More than 10%	More than 100lx
Chromaticness	R,G,B	More than 0.75cm×0.75cm	More than 10%	More than 100lx
	Y	More than 1.5cm×1.5cm	More than 10%	More than 100lx
		Less than 0.75cm×0.75cm	More than 20%	More than 100lx
Pure Blackness	R,G,B	More than 1.5cm×1.5cm	More than 10%	More than 100lx
		Less than 0.75cm×0.75cm	More than 10%	More than 500lx
			More than 20%	More than 100lx
	Y	More than 0.75cm×0.75cm	More than 10%	More than 100lx
Colour Mixing Ratio	G	More than 1.5cm×1.5cm	More than 10%	More than 100lx
		Less than 0.75cm×0.75cm	More than 20%	More than 100lx
	R,B,Y	More than 3cm×3cm	More than 10%	More than 100lx
		1.5cm×1.5cm	More than 20%	More than 100lx
		Less than 0.75cm×0.75cm ; Do not use it		

Table 2: The application criteria of colour difference and illuminance by font size for the elderly.

CONCLUSION

General adults in their 20s~30s were found to easily recognize characters on the whole according to the ‘difference in blackness, chromaticness and pure blackness.’ However, in the case of ‘the difference in colour’, a small size character (below 0.75cm×0.75cm) cannot be easily recognized in some cases even the colour mixing ratio exceeds the 20%. Even senior citizens aged above 65 are also showing a similar tendency to general adults in their 20s~30s. However, this study result shows that their legibility remarkably falls behind the general adults in their 20s~30s.

In general, the difference consequent on colour temperature is not big. Nevertheless, in the case of yellow, meticulous care is required in case of the application of low colour temperature like 3000K.

Generally, the higher the brightness, the better the legibility. an object, which is difficult to momentarily recognize in brightness of 500lx, could be possible to momentarily recognize in brightness of 1000lx. In addition, the illuminance below 100lx might weaken legibility even though the difference in individual mixing ratios is more than 20%, and therefore, care is required at the time of application of illuminance.

This study result revealed that on the whole, the smaller the character size, the more time is required in recognizing it, or it was difficult to recognize the content despite the elapse of time. Particularly, confusion could be aroused in the case of a small size character below 0.75cm×0.75cm in the range of sight of 2 meters. In contrast, a character above 3cm×3cm is available for momentary recognition with ease regardless of the difference in the colour mixing ratio, colour temperature of lighting, and illuminance. In case a similar colour, or low illuminance (nevertheless, more than 100lx) should be applied, it would be better to apply more than 3cm×3cm size character at least.

In case of a colour, Green is unrivalled in legibility. In addition, looking into the legibility through the difference consequent on the mixing ratio, the difference (difference in value) consequent on the blackness ratio produces the best legibility while the difference consequent on the colour tone ratio produces the worst legibility. Notably, in the case of Yellow and Blue, there could be a problem in legibility consequent on the difference in the colour mixing ratio, so it is desirable to make a big difference in colours.

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The spring natural lighting chromaticity in interior: a case study for elderly people

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ABSTRACT

Natural light, in terms of quantity, duration and time, distribution, direction and spectral power distribution, is important for non-visual processes by setting the principal biological clock to the day/night cycles and by enabling the regulation of body (heart rate, body temperature, blood pressure), mind (cognitive performances, subjective alertness, short-term memory) and behaviour (mood, appetite, wakefulness/sleep). In home environments, elderly people can suffer from the disruption of the circadian system due to the limited availability of natural light from the windows and due to the natural age modifications: the yellowing of the crystalline lenses along with the reduction of the number of neurons in the retina and in the suprachiasmatic nucleus (SCN). This paper describes the methodology of the measurements conducted through a field case study in a real domestic environment and it discusses the results of the availability and features of the natural light experienced by elderly people. This case study shows that elderly people experience insufficient levels of natural light during the morning in the spring season, with a western orientation of the windows and mainly overcast sky conditions. In these conditions, the circadian activation occurs only in the afternoon but this is inadequate for the correct regulation of the biological clock.

Keywords: *Circadian Lighting, Spectral Power Distribution, Lighting Design, Spring Equinox, NIF effects*

INTRODUCTION

Light is useful for tuning the principal biological clock of humans to the cycles of night and day. By influencing non-image forming (NIF) processes, the main features of light, in terms of quantity, duration, time, distribution, direction and spectral power distribution (SPD) regulate physical, mental and behavioural functioning.

The NIF effects of natural and artificial light have been extensively studied in fields of application such as workplaces, education and healthcare. Differently, the research has performed limited studies in domestic interior applications but the interest is growing (Cajochen 2014), in particular considering the needs of lighting for the circadian system of elderly people.

THEORY

In older adults, circadian disruptions derive from age degenerations of visual and cognitive systems (Rea *et al*. 2007). The lens of elderly people becomes thicker and more yellow (more than 60 years old) (Kessel *et al*. 2010), resulting in the reduction of the quantity of light reaching the retina and with a transformation of its spectral quality: UV and short wavelengths of the spectrum are strongly reduced. Differently, when older adults have had cataract surgery, they use Yellow Intraocular Lenses (Yellow IOL) which mimic the spectral transmission of the human lens, protecting the macula from potentially damaging UV wavelengths (Artigas *et al*. 2012). The cognitive changes in the elderly derive from the reduction of the number of neurons in the retina and in the suprachiasmatic nucleus (SCN).

Owing to this reduced amount of light that stimulates the endogenous circadian system of elderly people, physiological and neuropsychological disruptions can occur: insomnia, reduction of physical health, limited cognitive performance along with the decrease of mental well-being and depression.

In order to understand the contribution of natural light for the well-being of independent elderly people and the NIF activation in the domestic interiors, the natural light conditions have been investigated through a field case study.

Figure 1: Evaluated area and measured points for the evaluation of the NIF of natural lighting.

EXPERIMENT

The field case study has been conducted in a living room - kitchen where older adults spend most of their daily life. It presents a west exposure inside an apartment on the third floor of a residential building in Milan (Lat. 45.504044 - Long. 9.177164). To assess the contribution of natural light in terms of NIF effects, measurements of Illuminance at the Eye (E_{eye}), Spectral Power Distribution (SPD) and Chromaticity were performed with a portable Spectra-radiometer Minolta CL-500. Luminance has been evaluated with a Luminance-meter Minolta LS-100 and a Canon Eos 550D photo-camera equipped with a standard lens (18-55mm) along with Luminance HDR and HdrScope softwares for calibrating HDR images and extracting Luminance images. All the measurements were taken from four different observation positions (Figure 1) and conducted every hour from sunrise to sunset (8:00 a.m. – 6:00 p.m.) during the course of a day near the astronomical spring equinox (March 22nd, 2017).

RESULTS AND DISCUSSION

The correlated colour temperature (CCT) of the natural light depends on weather, sky conditions, season and hour. The measurements of CCT in the four observation positions range from 3877K to 6413K with a mean value of 4876K. This wide range derives from the contribution of indirect lighting with consequent inter-reflections of the colours of furniture and floor in overcast sky conditions and from the contribution of direct lighting in clear sky conditions (warmer CCT at 16.00 p.m.). The values measured in the positions which are not facing the windows (P2 - P4) or in the positions located in the most internal part of the room and distant from the interception of direct light (P1) present lower CCT if compared to the one directed towards the windows (P3). (Table 1).

Timing (hours)	Sky conditions	P1	P2	P3	P4	Average
08.00	overcast	-	4984K	5668K	5146K	5266K
09.00	overcast	-	4816K	5417K	4929K	5054K
10.00	overcast	4856K	4723K	5264K	4792K	4909K
11.00	overcast	4993K	4694K	5264K	4767K	4929K
12.00	overcast	4683K	4654K	5212K	4724K	4818K
13.00	overcast	4625K	4639K	5209K	4698K	4793K
14.00	overcast	4657K	4514K	5075K	4561K	4702K
15.00	intermediate	4583K	4490K	5175K	4607K	4714K
16.00	clear	4287K	3941K	4704K	3877K	4202K
17.00	overcast	4797K	4693K	5112K	4736K	4834K
18.00	overcast	-	5622K	6413K	5890K	5975K
Average	-	4685K	4706K	5319K	4793K	4876K

Table 1: CCT measurements of P1-P4 observation points and average values.

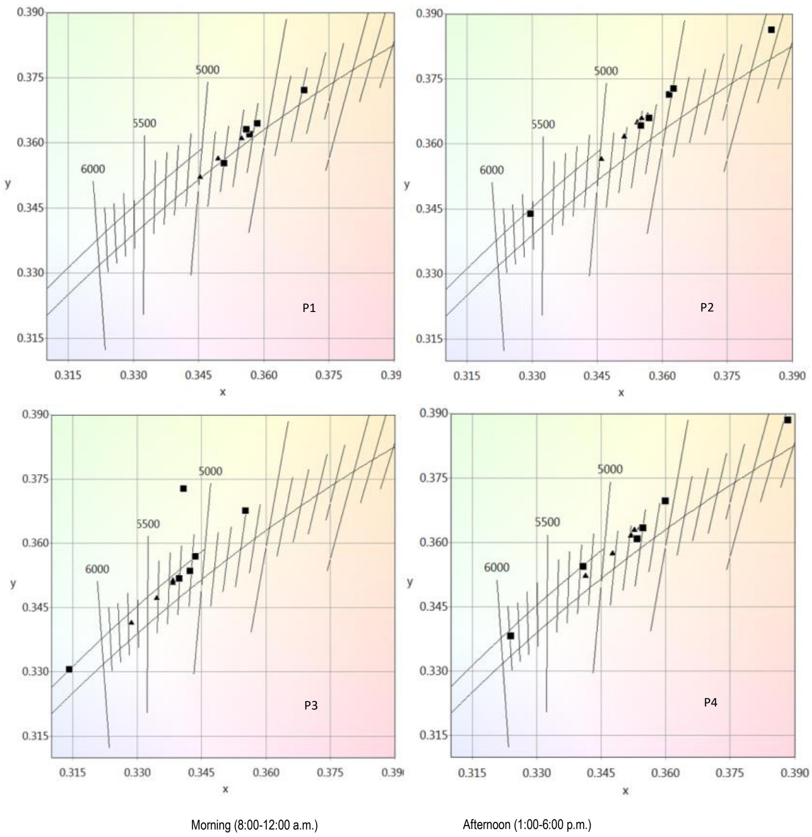

Figure 2: Measurements of chromaticity from different points of observation.

Chromaticity measurements also allow to evaluate the influence of the inter-reflections of the colours of the furniture and the floor on the SPD of the natural light and the variation of the sky conditions (Figure 2). When the influence of the inter-reflection is high, occurring in the furthest position from the windows (P1), the chromaticity of the light is more uniformly distributed around the daylight locus. Wider deviations are due to the observation direction oriented towards the windows and to the different sky conditions which occurred during the measurements mainly in the afternoon (overcast, intermediate and clear sky).

The photopic E_{eye} has been calculated in relation to the SPD of the natural light to evaluate the NIF effects, by taking into account the circadian model of light's sensitivity proposed by Rea (Rea *et al*. 2012; Rea and Figueiro, 2013), between others (Gall, 2004; Lucas *et al*. 2014). First, to calculate the light that reaches the cornea of elderly people, the spectral transmission curve of the Yellow IOL has been considered (Artigas *et al*. 2012). Then the appropriate equivalence circadian-lux has been established: a simple ramp function has been used as a model for representing the probability that the E_{eye}, maintained for a sufficient period of time and from a given direction of observation, is enough to affect the circadian system. Low probability (0%) means below the minimum threshold limit, high probability (100%) above the upper limit referred to the D55 illuminant and there is a linear interpolation between these values (Andersen *et al*. 2012). Finally, the minimum and maximum thresholds for the measured CCTs for each observer positions were derived (Figure 3).

From the measured values at E_{eye} in the different observation positions and at different CCT, the NIF activation never occurs throughout the entire course of the day in the spring season if the subject is positioned in the most distant observation position in the room (P1), since all the values are below the minimum threshold. The other three observation positions (P2-P3-P4) result to have a circadian activation between 3:00 p.m. and 6:00 p.m. This activation occurs in the afternoon due to the exposure of the windows (oriented to the west) and it is inadequate for the correct functioning of the biological clock. In particular, the observation position facing the two windows (P3) and the one which is oriented towards the French windows (P4) result to be activated above the maximum threshold at 4:00 p.m. Luminance and illuminance measurements were taken with a white curtains covering the glass area of the French windows to reduce the glare from direct vision of the luminous sky. This effect occurs at 4:00 p.m.: the small window (without curtains) has a luminance level up to 8000 cd/m^2 (Figure 4). When the circadian activation is required, in the morning hours, the measurement is always below the minimum threshold for all observation positions (Figure 3).

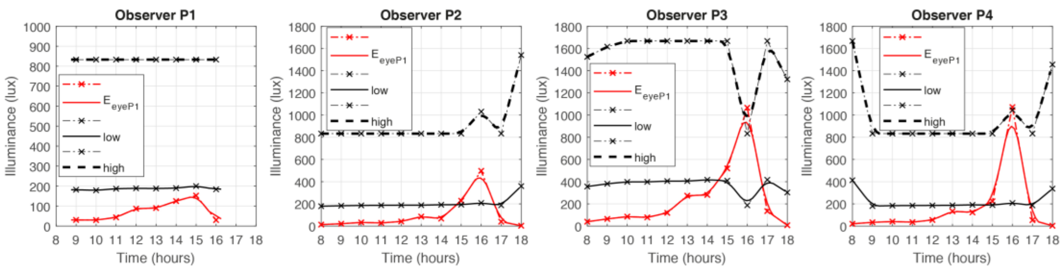

Figure 3: Measurements of illuminance from points of observation and NIF low and high activation.

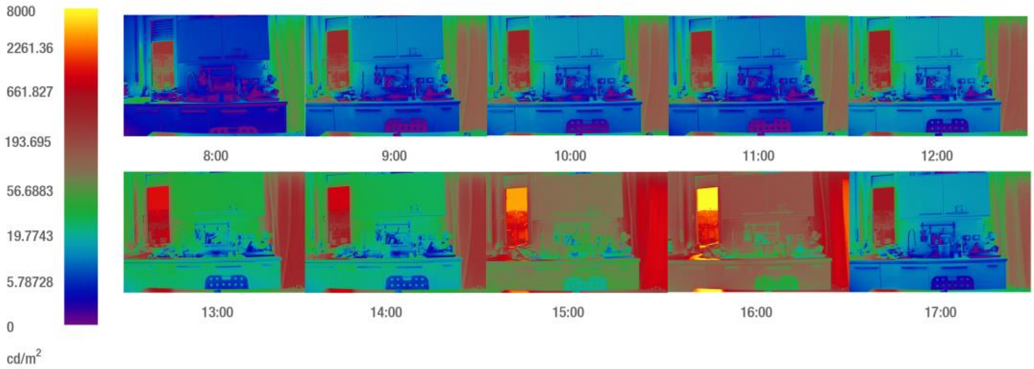

Figure 4: Measured luminance of natural light from P3 observation position.

CONCLUSION

Even if this is a single case study, the paper presents preliminary contributions about the NIF effects of natural light for elderly people in domestic applications which are seldom considered by circadian studies.

The results show that, in interiors, elderly people could be exposed to low levels of natural light in the spring season during the morning hours which are mostly important for the activation of NIF responses and so for the synchronization of their circadian clock. These results derive both from the specific windows exposure of the real environment taken as case study (west orientation) and from the sky conditions which occurred during the measurements (mostly overcast sky). Circadian activation occurs through the natural light when the observers' gaze is perpendicularly oriented towards the windows, at very close range, in the afternoon. The effectiveness of natural light for the circadian system decreases in the more distant areas of the room from the windows, due to lower direct light penetration and higher levels of indirect lighting with an almost constant CCT during the day.

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Effect of colour purity of LED light on time-sense perception

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ABSTRACT
In this study, we aim to clarify the effect of colour purity and LED lighting chromatic colours on long-interval time sense perceptions. In our experiments, white light and three purity patterns were used for red, green, blue, yellow, cyan and magenta, respectively. The colour purity patterns of the chromatic light were 50, 75, and 100%. Once the task had started, subjects were asked to state when they believed that 1200 seconds has passed, after which their time perception was compared to the actual elapsed time. The results showed that declaration times were longer than 1200 seconds for all light colours. Moreover, except for red 75, green 75/50, blue 100, cyan 50, and magenta 75, the times were felt to be shorter than under white light under chromatic light colours. However, no significant differences were observed for each light colour.

Keywords: *colour purity, light colours, LED, time sense, chromatic colour*

INTRODUCTION
The use of light-emitting diode (LED) lighting has now become widespread. Such light sources emit light in the primary colours of red, green, and blue, and are thus capable of reproducing most chromatic colours. Such light colours have been found to have both physical and psychological effects on human beings. For example, some studies have reported that long-wavelength (red) light increases alertness in the daytime [1], [2]. In another study, Katsuura [3] reported that experimental subjects judged 180 seconds to be shorter in a red lighting environment than in a blue lighting environment. On the other hand, no comparisons with white colour lighting have been studied, and if waiting time is assumed, 180 seconds may be too short to be considered appropriate. Takahashi *et al*. [4] showed that high-purity green lighting tends to lengthen time perception of 600 seconds. However, the light colours used in those experiments were limited to high-purity red, green, blue, and white. Taking the above studies into consideration, this study

aims to clarify the effect of colour purity and LED lighting chromatic colours on long-interval time sense perceptions.

EXPERIMENTAL

In our experiments, white (W) light and three purity patterns were used for red (R), green (G), blue (B), yellow (Y), cyan (C) and magenta (M), respectively. For each colour hue direction, colour purity was set to 100%, which is defined as the colour having the highest purity that can be represented by the present LED light sources. The distance to the main wavelength of the maximum purity of each hue was then divided into four equal parts, with purity patterns set at 25, 50, 75, and 100%. In this study, the top three colour purity patterns (25% excepted) were used. The light colours used in this experiment are marked on the chromaticity diagram shown in Figure 1. The illuminance was adjusted to 300 lx at a height of 80 cm from the floor.

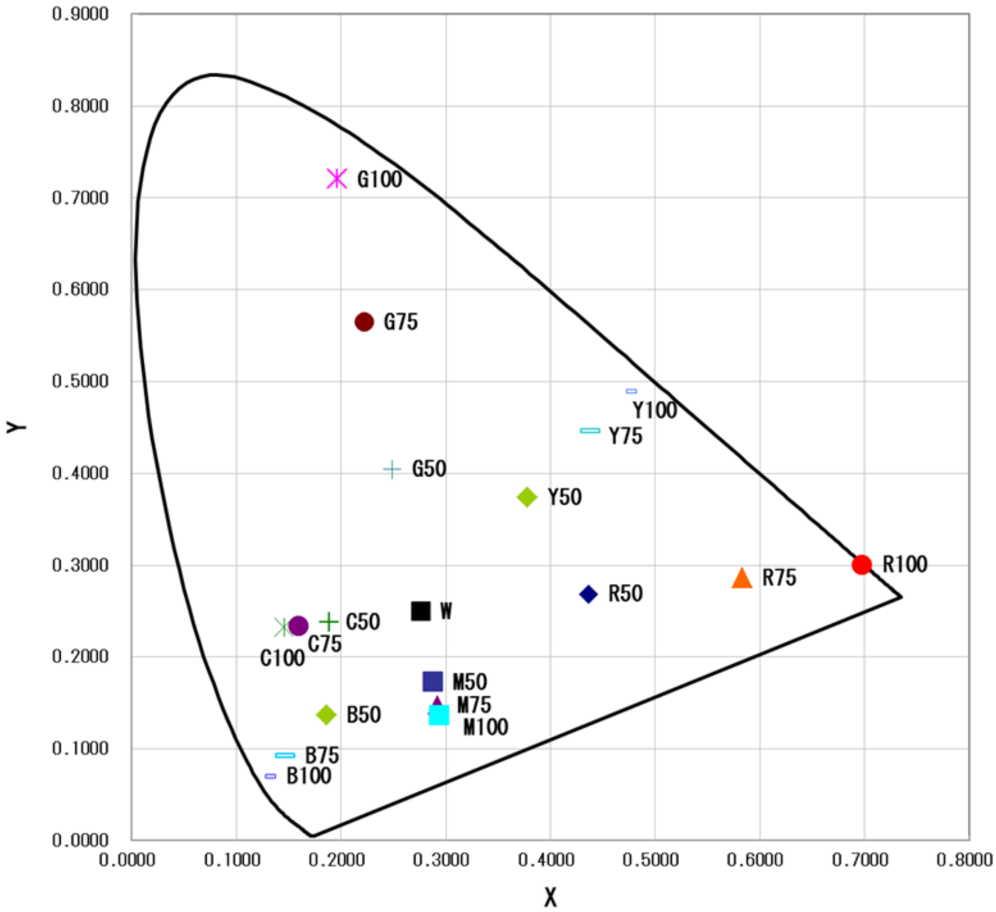

Figure 1: Experimental light colours on the CIE 1931 chromaticity diagram.

The selected task in our experiments was resting in a chair. Once the task had started, subjects were asked to state when they believed that 1200 seconds has passed, after which their time perception was compared to the actual elapsed time. From electrocardiogram (ECG) data, which were recorded throughout the experiments, low-frequency/high-frequency (LF/HF) values, which act as sympathetic nervous function indicators, were extracted. Flicker values were measured before and after the experiment in order to gauge eyestrain. Subjective evaluations were conducted before and after the experiment using the semantic differential (SD) method. In this assessment, 12 pairs of words were employed: not uncomfortable/uncomfortable, not sleepy/sleepy, bright/dark, unoppressive/oppressive, warm/cool, calm/restless, stress-free/stressful, rested eyes/tired eyes, feels short/feels long, like/dislike, strong/weak, non-glaring/glaring. The subjects were five males and one female in their twenties, all of whom reported having normal colour vision.

The following procedure was used in the experiment:

(1) The subject was given a flicker value test.

(2) The subject was given 10 minutes to adapt to the chromatic lighting of the experimental environment, which included a subjective evaluation after seven minutes had elapsed.

(3) The subject was instructed to rest in a chair for 30 minutes and asked to declare when he/she felt 1200 seconds had passed. The subject's ECG data was recorded during this period.

(4) The subjective was given a subjective evaluation.

(5) The subject was given a second flicker value test.

(6) Steps (1) to (5) were repeated for each light colour, which were chosen at random to avoid order effects.

RESULTS AND DISCUSSION

One-factor analysis of variance (ANOVA) was performed in this study. The factor was light colour, and multiple comparisons were performed using Fisher's least significant difference (LSD) method. Analyses were conducted to determine significant differences between white light and the other colours. The results are shown in the following figures, in which the error bars represent the standard error.

In Figure 2, which shows the time-sense measurements, we can see that the declaration times were over 1200 seconds for all light colours. This result indicates that the subjects felt that time spans were shorter. Moreover, except for red 75, green 75/50, blue 100, cyan 50, and magenta 75, the times were felt to be shorter than under white light under chromatic light colours. However, no significant differences were observed for each light colour. The results of Figure 3, which shows the relationship between the irradiance of each light colour and the declaration times, indicates that there is no relationship between those factors because the decision coefficients are extremely small.

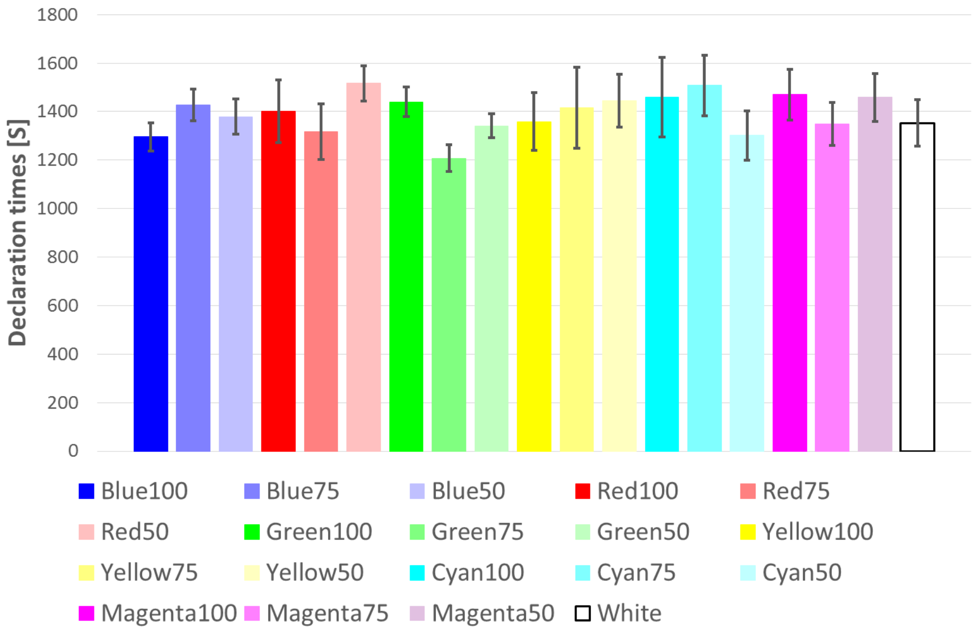

Figure 2: Declaration times.

Figure 4 shows the relationship between the declaration times and the before/after experiment flicker value differences. These results show that flicker value differences are small when declaration times are long. In other words, little eyestrain occurs when the time perceptions were short. Here, the correlation between irradiance and flicker value difference was investigated and, at 0.17, found to be negligible.

In the subjective evaluation, a weak correlation was shown between the words of "feels short/feels long" and the declaration times. In the ECG measurement, LF/HF values could not be obtained because the LF component was susceptible to external factors and numerous error values were detected. Hence, the effect of colour purity on time-sense perception was not observed in this study. However, it is thought that it will be necessary to increase the number of subjects in future studies because our results suggest that there are light colours that can shorten time perception more than white light.

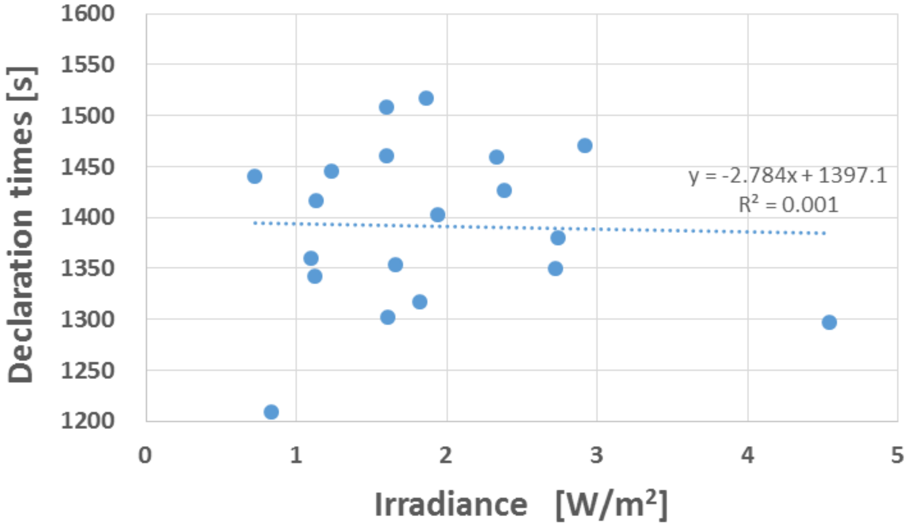

Figure 3: Relationship between irradiance of each light colour and declaration times.

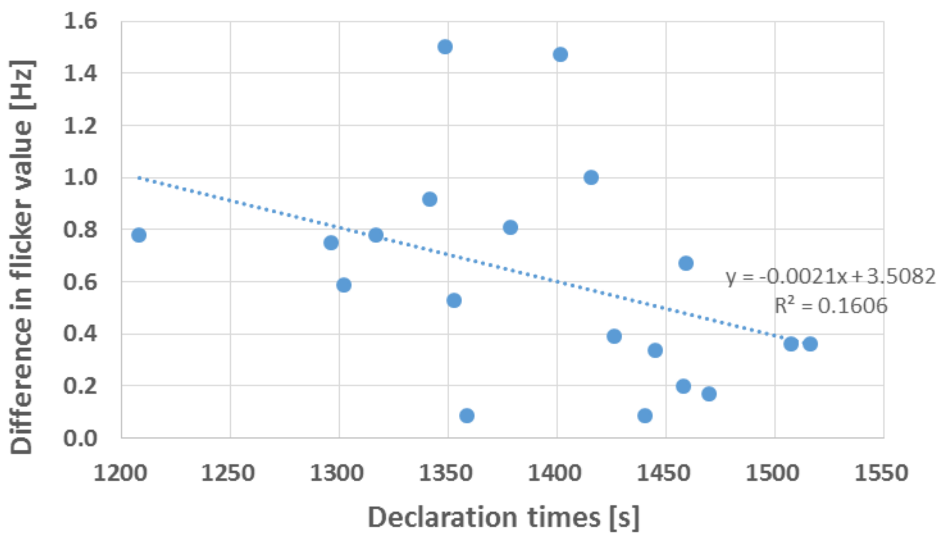

Figure 4: Relationship between differences in flicker value before and after the experiment and the declaration times.

CONCLUSION

In this study, measurements were conducted for the purpose of clarifying the effect of colour purity of LED light on time-sense perception. The results are summarized as follows:

(1) Colour purity had no observable effect on time-sense perception.

(2) It is possible that time-sense perceptions may be shortened under light colours that produce less eyestrain.

This study was approved by the Ethical Review Board for the use of human subjects of Kanagawa Institute of Technology (No. 20170403-03).

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Colour and Culture

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Colour, Geometry and Consciousness

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ABSTRACT
This paper explores the ways in which colours are related to form and the ways in which both interact to express and evoke different states of consciousness. By narrating the different ways in which colours and forms are used in Tibetan Buddhism and in recent developments in new mathematics of consciousness, this paper suggests that colours and forms can be used to bring harmony on a physical, emotional, mental and spiritual level. This paper also suggests that rainbow colours and light with particular geometrical forms such as a circle or the Mobius ring can break traditional and dualistic patterns of thinking and induce realization of nonduality. This view advances our understanding regarding aesthetic experience as well as the relations between geometry, colours and consciousness.

Keywords: *consciousness, Buddhism, spirituality, mathematics, aesthetics*

INTRODUCTION

Colours have been used in spiritual traditions not only to symbolize aspects of the external and inner environment but also as means to transform them. This paper provides a short survey of these applications in Tibetan Buddhism and offers a new angle by attending to the ways in which colours are used with geometry to reflect and to induce varying levels of awareness. This paper therefore advances our understanding regarding the connections between colour, form, and consciousness.

In recent years an influx of research on the impact of Buddhist practice on health, well-being and awareness. Using the supposedly scientific term "mindfulness" and applying advanced technology such as fMRI brain scans as well as more traditional research methods such as experiments and interviews, meta studies show that Buddhist practices increase concentration, compassion, happiness, well-being and physical health (Weaver *et al*, 2008; Gu *et al*, 2015). Testimonies also reveal that advanced practioners develop ability to control body temperature, and even health, or even manner of death. Much of the evidence gathered on these more extraordinary states of consciousness looked at Tibetan Buddhism (Sogyal, 2012). Unlike the Sutric vehicle of Buddhism that is commonly associated with renunciation, Tibetan vehicles do not try to let go of things in space but attempt to transform, transcend and merge with them. To do that, practioners of Tibetan Buddhism work with the entire range of phenomena: sound, sensations as well as vision and colours. From the monks' red robes to the intricate and colourful visualizations—colours play an important role in Tibetan culture and spiritual practice. Tibetan Buddhism is therefore an interesting arena of research for those interested in colours and consciousness.

THEORY

One way to understand how colours and forms are used in Tibetan Buddhism is to understand the Tibetans' view of the elements. The revered Bön and Dzogchen teacher, Tenzin Wangyal Rinpoche, explains in his book "Healing with form, energy, and light" (2002) — that the elements describe certain qualities and modes of action by analogy to familiar elements from nature. They are associated with colour, form, as well as aspects of experience such as sound and time. They are also traditionally associated with different emotions and thinking styles, and they ultimately give rise to the five senses, the five fields of sensual experience and the five extensions of the body. The five basic elements are: earth—symbolized as yellow and associated with solidity; water—white or blue and () associated with cohesion; fire – red and temperature; air—symbolized as green and associated with movement; and space (white or blue) is the dimension that accommodates the other four elements.

Another, most subtle dimension of the colours or the elements is that of the five pure lights. The Six Lamps and The Mirror of the Luminous Mind are two important texts from the Zhang Zhung Nyan Gyud, the primary cycle of Dzogchen teachings, also called The Great Perfection which is considered the highest path of practice in Tibetan Buddhism. Explanation of practice with colours in Dzogcehn will be given later, but the understanding of colours and light in relation to consciousness according to this approach is pertinent GIVEN the ultimate view of Dzogchen contains all others.

According to Wangyal's reading of these texts, the five pure lights arise at the moment of conception, in which pure awareness is still without identity. These lights are aspects of primordial luminosity and are more subtle than visible light or perceptible energy, yet they are the energies from which all energies, including visible light, arise. These lights are associated with different states of awareness and their ultimate and most subtle dimension is aligned with pure awareness that is nondual. If the five pure lights are perceived dualistically: as object of the perceiving mind, they become more substantial. While the lights themselves do not change, the individual perceives them as more gross until they are reified and become more distinct and materialize as the different colours and dimensions of the external reality. When they materialize internally, they thicken and form the organs, the five senses, and branches of the body. These lights are also associated with emotions. When deluded, they are associated with what Buddhists teachings call "five negative emotions" or the Five Poisons: anger, desire, jealousy, pride, and delusion. In in a more clear state of mind, they can be associated with the Five Wisdoms (Palzang, 2004).

Wangyal emphasizes (Ibid) that the way in which the lights materialize is not a mythical or historical account, but explanation of different ways of being in the world. How one relates to the five pure lights as represented by colours is associated with different levels of awareness. When the five pure lights are recognized as a non-dual, eternal manifestation of the pure basis of existence (kunzhi), nirvana begins. If the five pure lights are perceived dualistically and are thought to exist externally as objects of subject then one is ignorant of the nature of consciousness and reality; thus, the cycle of life-death and suffering ensues. The goal of Buddhist teaching is liberation from suffering, and according to Dzogchen teachings this can be achieved BY integrating the immediate experience with non-dual, natural awareness. The five pure lights can therefore be seen as A means to practice with experience, both subtle and gross.

According to Buddhist philosophy, all beings and things are empty of inherent existence; recognizing the fleeting and interdependent nature of all phenomena is important for spiritual realization. Wangyal (Ibid) explains that understanding the inclusiveness of the elements, as symbolized by colours, means that one can recognize that everything arises together, that nothing is completely separate from anything else, and that everything is affected by everything else. This is the ultimate empty and interdependent nature of the physical and internal environment.

The different vehicles of Tibetan Buddhism use the understanding regarding colours and the elements in different ways. In the shamanic practices, also called external practices, these elements are associated with nature and other beings. On the internal level, these elements are associated with more subtle energies and are manipulated through yogic practices involving posture, breathing, visualization, and mantras. The most subtle dimension of the elements is the radiance of being, the "five pure lights" aspect of luminosity that is inseparably united with emptiness. While these three paths of practice are separated conceptually, they are not mutually exclusive and can be practiced together. Below is a survey of the different approaches to colours according to the different vehicles.

Shamanic practices refer to the approach meant to harmonize the relationship between the individual and the environment through work with the sacred energies underlying nature. These practices are not primarily oriented to bringing enlightenment. They are known as "causal vehicles" because they create the causes and foundations to practice the "resultant vehicles"—Sutra, Tantra, and Dzogchen.

Shamanic practices influence the symbolic level of external elements and rituals. For example, herbs associated with certain elemental energies might be consumed internally and energy might be collected from the raw elements. In a variety of practices, one connects with the external elements, internalizes their qualities, radiates them to the environment and ultimately unites with them. For example, when bathing in water one can feel the water element being absorbed into the body, the body becomes fluid, and then radiates that quality into the world until there is no distinction between one's body body and the water and the greater external environment. At this level, emphasizes Wangyal, "connecting is healing" (2002, p. 1047). Since on the shamanic path the elements are considered a part of the soul, connecting with the elements and internalizing their qualities heal the soul. Merging with the elements and radiating them back is an important practice in Tantra as well and is often done through the symbolism of colours (e.g., merging and radiating blue or white instead of actual water).

Experiencing beauty and appreciating nature are other ways of connecting with the elements and enhancing health and life force. A shamanic approach therefore emphasizes mindful appreciation of experience even if it does not arise spontaneously. In the classic dialogue Gorgias, Plato compares rhetoric to cookery and cosmetics, hence reflecting and creating the famous Western hierarchical binary of body and aesthetics as lowly in comparison to the separate and superior mind and ethics (philosophy). The shamanic approach, on the other hand, does not separate the self from nature nor body from mind, and aesthetic experience is similarly integrated with health and spirit. Colours, as associated with the natural elements therefore have an important value. If aesthetic pleasure is important not only on a superficial level but can increase one's life force, then colours are more than superficial ornaments and can be understood as food for the soul.

If the path of shamanism is about harmony with nature, the path of Tantra is the path of transformation. In Sutra, the nature of reality is described in terms of the inseparable union of emptiness and form. In Dzogchen it is awareness and emptiness, In Tantra, it is bliss and emptiness. In Tantra, all practices transform experience into bliss. Physical sensations are turned into heat and pleasure, vision is transformed into divine visions, and sounds are transformed into mantras. The five negative emotions are transformed into five positive qualities, the physical body is transformed into a body of light and the suffering being is transformed into the enlightened Buddha.

Tantra transforms experience with energy work: the opening of the chakras, unblocking energy channels, and activating the different pranas (energies) and mind aspect. This is done through a variety of yogic practices such as physical movements, breathing, visualizations and sounds. Colours are essential dimension of these practices and they are strategically used. For example, visualization of specific colours in coordination with the breath can balance certain energies and elements. Geometry is also used in conjunction with light and colour. "Tigle" (a "sphere" of light or "circle" of light) is a form often visualized in a chakra or the channels. A tigle in the heart may represent compassion and a tigle moving up the central channel may represent non-dual experience. Single Syllables (seed syllables) are also frequently used. They have more form than the pure light of the tigle, and since they represent distinct qualities they are visualized to evoke them. The quality is already inherent in the mind but the visualization enables its manifestation in the same way that light and heat can arouse the sprouting of a plant from a seed.

In some practices the visualization moves progressively through five distinct lights, from pure light in all colours to complex geometrical forms to no form. The long life practice of Mandarava, which was discovered by the great Dzogchen master Chogyal Namkhai Norbu Rinpoche (2014), is aimed at promoting health and clarity awareness. In it, one visualizes all colours radiating from a seed syllable at one of the chakras and I reflected back. Mantra moves around the body in an interesting form: one circle spins counter clock-wise around one chakra, while another circle spins clock wise around another chakra but both circles are connected and move in synchronicity. The use of colours in conjunction with the twisted form probably facilitate the movement from colours to light, distinction to unity, from dual to nondual perception.

In their innovative work on consciousness, Klein and Maimon develop a new mathematical language that explains the movement from a dual to a nondual view, from a state of antagonistic contradictions to unified state in which they are not separate (2016, 2017). Klein and Maimon use the geometric example of the Mobius strip to illustrate their model of consciousness and the shifts in dimensions and perspectives. To understand it, we need to first visualize a normal ring of two sides and four edges, painted black from its internal side and white from its external side. By opening the ring, twisting the strip and bringing the white edge and the black edge together, a new three dimensional form is being created known as "the Mobius strip". In it, the black side morphs into the white side as the inner side morphs into the outer side. The twist had changed the ring and the clear distinctions between black and white, inner and outer have ceased to be valid. Points along the strip that were opposite to one another now move towards one another. A new possibility that Maimon calls the "fifth dimension" (2016) opens up if we accept the "twist."

The geometry of the form and the ring change the nature of the colours- from distinct entities to an expression of flux and fusion. The form in conjunction with the colours move the experience from separateness into unity that does not dismiss the existence of the colours as colours but opens our perception of them to something more subtle and whole. Indeed, the Mobius strip is similar to the form used in the Mandarava practice above in which the movement to nonduality is considered one of the consequences of practice.

Dzogchen, also called the great Perfection, is Tibet's principal tradition of gnostic mysticism. It describes itself as the pinnacle of attainment of Buddhist yoga, yet it also maintains distance from traditional Buddhism at it is said to be beyond religious practice and immanent to human capacity (Dowman, 2007). Dzogchen teaches that the basis of all phenomena is inseparable emptiness and luminosity. Emptiness means that all beings and things have no essential, distinct identity. Entities exist but their identity is not intrinsic but situational and transitory. Luminosity is both the concept and the sensual experience that best represent awareness. Emptiness and luminosity are inseparable: emptiness is luminous and luminosity is empty. In Dzogchen, this is expressed as the capacity for endless manifestations of phenomena that are all essentially empty and luminous. According to Wangyal (2002), emptiness and luminosity can be represented as space and light. Emptiness is space out of which all phenomena arise and to which all phenomena cease. Light is the display of the five lights, the five elements, the manifestation of all things and all experiences. The revelation of the innate awareness that allows the light to shine out is called in Tibetan rigpa (Dowman, 2007).

Geometrically, the inseparable emptiness and luminosity that is the true nature of all phenomena is represented in Dzogchen as a single sphere of pure light. It is single because it is non-dual, it has no boundaries or divisions, no inside or outside. Though it is non-dual, the elemental energies ceaselessly manifest in it. For this reason, it is often painted as a sphere of rainbow light made of the five elemental energies. Light is used as a symbol because it is the least substantial of all things perceived through the senses and because the nature of mind is said to be radiant and clear like light. All experiences appear in the light of awareness. When light as the pure elemental energy meets awareness it reveals form. With dualistic awareness, meaning is projected into these forms and they are recognized as separate and independent, and one ultimately projects feelings of longing towards certain forms or anger, hate and aversion towards others.

The Tibetan tradition identifies two stages of attainment. The first is the mind's spontaneous function of disengagement from sensory and mental objects of attachment and simultaneous self-identity with the light of which they are made. This is called Breaking Through, or Cutting Through (trekcho), into the original purity——where natural perfection lies. Perfection of this state is identified with "rainbow body" which presages corporeal dissolution at the moment of death, leaving only fingernails and hair behind. The second state is achieved through a practice called togel or Breaking Through in which the gap between the observing cogent mind and the experience of luminosity is eliminated. It is impossible to describe it here but it has a dimension of contemplation on light through its nuclear components. Dowman compare it to pixels running in a hologram (Ibid, p. xiv). This state is considered beyond causality and its zenith is "the body of great transformation" which entails longevity. These high states entail recognition of the luminous reality of all things and are expressed in the corporeality of all things: longevity or dissolution upon death. Although it is said that no practices can be done to achieve these states, the nonmeditation of trekcho and togel use light, colours and geometry.

EXPERIMENTAL

Tibetan Buddhism integrates colours and geometry as means of expressing the nature of reality for inducing their realization. Distinct colours, clearly articulated geometrical forms are associated with more gross view of reality that is also associated with projection of emotions onto reality, the blockage of energetic channels and lack of health. On this level, colours are used to evoke aesthetic pleasure that is perceived as nourishment for soul. Colours can also be used distinctively in a variety of ways (from nutrition to visualization) in order to balance elemental energies in the body and the environment. The movement towards nondual view in which body, mind and all phenomena are empty of inherent identity is represented through light. Colours are used here together as rainbow lights, and geometrical forms are round or in flux integrating colours, the inside and the outside to a point where they are no longer distinct. Conceptual thinking and identification with forms is accordingly deconstructed into clear and luminous nondual awareness. This understanding is also in accordance with new mathematics of consciousness. Understanding more deeply the connection between colours, geometry and consciousness therefore have important practical applications for mundane contexts such as nature preservation and urban aesthetics but also for education, health and spiritual development.

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Colours Used in Ancient Persian Rituals

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ABSTRACT

This study explores the colours used in the Ancient Persian Rituals by going through traditions, customs, and festivities of Mithraism and Zoroastrianism. The first section will discuss colours of Mithraism; for example, blue representing the colour of Monday; or purple representing the colour of *Mehregan* (one of the most important national celebrations of Persia). Next, it will introduce the colours of Zoroastrian rituals. For example, green (meaning peace, hope, and life) is considered a lucky colour and is used for celebrations such as engagements and weddings; or white is considered a clean and pure colour and is used in religious practices such as *Sedreh-Pushi* (putting on the *Sedreh* or the sacred clothing), or in festivities such as *Esfandgan* (Persian Women's/Mother's Day). In sum, this study will provide us a unique insight into this Ancient world and will help us understand colour values, practices, and aesthetics of the Persians and Persian Rituals.

Keywords: *Mithraism, Zoroastrianism, Colour, Persia, Rituals*

INTRODUCTION

There have been many customs and rituals practiced in ancient Persia – some of which are still practiced to this day in Iran (and other countries) – mainly related to Mithraism and Zoroastrianism. Mithraism was a religion centreed on the God Mithra. Zoroastrianism is one of the world's oldest religions. Ascribed to the teachings of the Iranian prophet Zarathustra, it exalts a deity of wisdom, Ahura Mazda (Wise Lord).

This study explores the colours used in the Ancient Persian Rituals by going through traditions, customs, and festivities of Mithraism and Zoroastrianism.

MITHRAIC RITUALS AND COLOURS

Mithra was the god of light, purity, goodness, truth, and occupied an important place in the faith of the ancient Aryans. The origins of Mithraism are still debated: the ancients called it Mysteries of Mithras, or because of its supposed Persian origins, Mysteries of the Persians. Regardless, the system of seven Mithraic grades of initiations belongs among the characteristic Mithraic structures, together with the tauroctony, and the mithraeum. (Chalupa, 2008). Here, the seven grades of initiations and the colours related to them will be discussed.

SEVEN GRADES OF INITIATIONS

1. Raven (Corax) | Black

   Although, Raven is the messenger; but in Persian literature, raven is also referred to as someone who is not trustworthy. Raven and the colour black being chosen as the first grade of initiation symbolize someone who is naïve and about to end the old life and enter a new life (of Mithraism). (Rizi et. al, 2015)
2. Nymphus (The bride) | Yellow and Gold

   This stage is referred to the Nymphus or the Bridgegroom. It relates to a person that does not exist in the real world: a bride of male sex. They were called “new light” (Chalupa, 2008), and the symbol was torch with colour of gold and yellow. Yellow is a colour that is constantly moving forward and thriving for more and this explains why the second grade is referred to as the bride, oil lamp, and yellow. (Rizi et. al, 2015)
3. Soldier (Miles) | Brown

   The God Mithra is always regarded as an invincible God, who as the Avesta records secures victory for his followers on the battlefield. In the struggle for the ultimate triumph of good over evil, Mithra is the associate of the God of good. Strictly speaking, every follower of the God was enrolled in his service, but the special initiation and the taking of the military oath set the seal on entrance into his ranks. (Vermaseren, 1963)

   In Santa Prisca in Rome, the soldier is represented dressed in brown. In Persian literature, brown defines social protection and security. (Rizi et. al, 2015)
4. Lion (Leo) | Purple

   The Lion wore a long cloak which is said to be in purple (the colour of Mithra). His symbol was a fire shovel. There are some specific references to the fire symbol at initiation. Porphyry records: When those who are being initiated as lions have honey instead of water poured over their hands to cleanse them, then are the hands kept pure of all evil as becomes an initiate. Since fire is purifying, the fitting ablution is administered to them, and they also cleanse his tongue of sin with honey. (Vermaseren, 1963)
5. Persian (Perses) | Grey

   In the paintings of Santa Prisca, the Persian is dressed in a grey tunic and placed under the particular protection of the moon (Vermaseren, 1963). To this day, farmers in Iran believe that moonlight has a positive effect on the growth of plants. The colour grey symbolizes silence and thinking; i.e. taking the time to make decisions, and not rushing into making them. (Rizi et. al, 2015)
6. The Courier of the Sun (Heliodromus) | Red, Yellow, and Blue

   In Avesta, Mithra and Sun are said to be united, to the point that Mithra is referred to as sun-light. In Ancient Rome and Greece, this was called Sol and Helios respectively. In Santa Prisca Sanctuary, He is wearing a red garment, with a yellow belt, and with his left hand he clasps to himself a blue globe. (Vermaseren, 1963) Red symbolizes power. Yellow symbolizes being merry, while blue embodies faith (Rizi et. al, 2015).

7. Pater, The Father | Purple
   This, the highest of the grades in Mithraism, is the deputy on earth of the God himself and is therefore portrayed clothed like Mithra, in purple. Purple is the colour of Mithra and is considered as an intellectual and spiritual colour. (Rizi et. al, 2015)

DAYS OF THE WEEK IN MITHRAIC PERSIA AND ITS RELATED COLOUR

In the Ancient Persia of Mithraism, the week started on Saturday and each day was symbolized with its own colour (Rizi et. al, 2015). Table 1

Day of the Week	Mithraic Name	Colour
Saturday	*Keyvanshid*	Indigo
Sunday	*Mehrshid*	Yellow
Monday	*Mahshid*	Blue
Tuesday	*Bahramshid*	Red
Wednesday	*Tirshid*	Orange
Thursday	*Hormozdshid*	Purple
Friday	*Nahidshid*	Green

Table 1. Colours of days of the week in Mithraism

FESTIVITIES AND CELEBRATIONS OF MITHRAISM

First, *Yalda* will be discussed. *Yalda* or Winter Solstice is the birth of Mithra falling on December 21-22. *Yalda* is a Syriac word meaning birth, and Mithra-worshipers adopted and used the term Yalda specifically with reference to the birth of Mithra. On this day, families and friends gather together. The table is decorated with fruits such as red pomegranate, apple, and watermelon; and yellow lemon and grape which all represent the colours of the sun and twilight. Sweets and dried nuts are decorated as well. (Figure 1)

Figure 1. Yalda-setting (Image taken from turmericsaffron blogspot).

Next, *Mehregan* will be discussed.

Mehregan is one of the most ancient Iranian festivals. It was originally an old-Iranian and pre-Zoroastrian feast consecrated to the sun-god (*Mehr*=Mithra). Today, Mehregan is celebrated on the sixteenth day of seventh month on the Persian Calendar, which falls on October 1st. As purple is the colour of Mithra, in the Acheamenid Persia, a purple table with dried fruits and grains would be decorated. (Rizi et. al, 2015)

ZOROASTRIAN RITUALS AND COLOURS

Zoroastrianism is one of the oldest living religions in the world, originating in Persia during the second millennium BCE. It has a very rich history and was the dominant religious tradition in pre-Islamic Iran. (Stausberg, 2008) Ascribed to the teachings of the Iranian prophet Zarathustra, it exalts a deity of wisdom, Ahura Mazda (Wise Lord).

ZOROASTRIAN INITIATION CEREMONY (*SEDREH-PUSHI,* i.e. putting on the *sedreh*)

This is the most sacred and significant ceremony in the life of a Zoroastrian. It has been said that *sedreh-pushi* has been amongst Zoroastrians since the old times, and is quite an ancient ritual. During this ceremony, the initiator makes a pledge to remain loyal to the religion and its moral values.

Sedreh is a white garment which both male and female wear (*push*i=wearing), and is given to a child during his/her initiation, which can take place around the 8th birthday to early teen years. The colour white resembles peace, and in Iran these are usually worn at fire temples. (Rizi et. al, 2015) (Figure 2 | *Photos taken at Museum of Zoroastrians History and Culture*).

Figure 2. *Sedreh* on the young-boy-mannequin (left) and part of the *Sedreh-pushi* Ritual (right).

WITNESSING (*GAVAHGIRI*) AND WEDDINGS

Gavah means witness and *gavahgiri* (marriage contract) means finding a witness for the marital bond between a man and a woman. *Gavahgiri* is among the most important celebrations held among Zoroastrians and is regarded as an issue of utmost importance.

The settings, from the tablecloth to decorations, are mainly in green. Green is considered a lucky colour meaning life, hope, and peace (Rizi et. al, 2015). (Figure 3)

Figure 3. Witnessing table and Wedding | *Photos taken at Museum of Zoroastrians History and Culture, Yazd.*

ZOROASTRIAN FESTIVITIES AND CELEBRATIONS

Persian calendar is a solar calendar based on Earth's movement around the sun (365 days, 5 months, 48 minutes, and 49 seconds). Each year is divided into 12 months of varying lengths. The first 6 months have 31 days, months 7 through 11 have 30 days, and the last month has 29 days in a common year and 30 in a leap year.

In Ancient Persia, each month had 30 days, and each day had a name – instead of a number. When the month and the day of the month had the same name, there would be a celebration on that day. These are celebrated to this day by Iranians, especially Zoroastrians. *Mehregan*, previously discussed, is one of these celebrations which is on the sixteenth day of the seventh month. A few more of these celebrations will be discussed.

TIRGAN

Tirgan is celebrated on *Tir* 10th (about July 1st) in which the name of the day is the same as the day of the month. *Tir* is the Yazad presiding over the star Sirius, brightest star in the sky, and of rain.

According to Herodotus: Iranian people never pollute water, never spit in it or even never wash their hands in a running water and don't consider it right for others to wash their hands in it, either.

One of the mythical principles of *Tirgan* celebration is *Arash Kamangir* (Arash, The Archer) myth and his courage to make peace and fix the boundary between Iran and Turan.

On this day, Zoroastrians tie a piece of yarn around their wrist or their index finger. This yarn is made up of colours of the rainbow which means love and peace. (Niknam, 2003)

Another ancient custom of *Tirgan* celebration is to splash water or rosewater on each other's head. It is said that in the *Sasanid* era of Persia, the end of the 7 years of drought coincided with this day and ever since people have been splashing water on each other to commemorate that rainy day.

ESFANDGAN OR SEPANDARMAZDGAN

Esfandgan, or *Sepandarmazdgan*, is an ancient Iranian celebration, dating back to the Persian Achaemenid Empire, devoted to earth, women, and mothers. It is celebrated on *Sepandarmazd* Day in the month of *Esfand*, the last month of the Iranian calendar, and falls on February 18th. This day is dedicated to *Spandarmad*, deity of Earth. Earth is the source of life, birth, piety, and purity which are all the qualities hidden in mothers and women. Birouni (937-1408), in his book

Asarolbaghiye, introduces *Esfandgan* as Women's Day in which men gave presents to their wives. It is also mentioned that people tried to make the earth clean or cultivate a plant. Zoroastrian priests wear all white on this day. (Rizi et. al, 2015)

CONCLUSION

There have been many customs and rituals practiced in Ancient Persia – some of which are practiced to this day. This paper focused on some of these rituals and the colours related to them. It was observed that red, yellow, and purple (colour of Mithra) are the colours used in celebrations related to Mithra; such as *Yalda* or *Mehregan*. It was further observed that green is considered a lucky colour in Zoroastrianism used in wedding rituals; and white is a scared colour, the colour of *Sedreh* or sacred clothing, used by Zoroastrian priests in celebrations and festivities such as Esfandgan.

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colour & human comfort

Colour-word associations: University undergraduate prospectus as a case study

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ABSTRACT

Colour plays an important role in conveying meaning and is today ubiquitous in all forms of visual communication, yet little is known about the relationship between semantic networks and colours. The study's objective was to analyse word-colour associations to evaluate their consensus from which a structure would emerge. One hundred and forty-five words were selected from a University undergraduate prospectus and nine colour samples evenly distributed on the colour wheel were used. Eighty-five undergraduate students were asked to indicate which of the nine colours they most associate with each of the 145 key words. A correspondence analysis revealed a three-dimensional structure accounting for 78% of the variance. The two first dimensions provided a triangular arrangement associating colours to semantic categories with green associated to natural environment, red and blue to professional responsibilities and yellow and pink to youth and creativity.

Keywords: *colour-word association, colour symbolism, correspondence analysis.*

INTRODUCTION

In cognitive science, colour is considered as a visual elementary feature just like shape, movement, depth, orientation or contrast. These features are processed automatically at a pre-attentive stage corresponding to an early stage in the visual system [1]. Yet, compared to the other elementary features, colour has an immediate perceptual, cognitive and emotional significance in human experience [2] and a powerful symbolic function. Archeological finds in southeast Spain dating from 115,000 years ago, show that red and yellow ochres were included in complex colourant mixtures that are accepted by the scientific community as proxies for symbolic behaviours [3].

Hence, together with the development of the most elaborated system, i.e., the articulate language, colour symbolism is at the roots of human symbolic behaviour.

It is therefore not surprising that today in laboratory conditions participants find quite natural to associate words to colours. Providing eight NSC colour samples sampling the entire colour wheel, in a free association task, Indian participants were asked to write as many words they could associate to a given colour in 60 seconds [4]. Based on the semantic word categories, three types of association were identified: colours associated to natural objects that maintain relation of physical similarity with their referent (green-grass, red-fire etc..) colours associated to concepts that maintain relation of conventionality defined by a given cultural consensus (red-power; orange-puja inspiration etc..) and words associated with man-made objects that are also conventional relationships with possibly a more restricted consensus limited to sub-cultures (denim-blue).

Conventional as opposed to physical relationship change with the culture, this change is well known of the marketers. For instance, global marketers are aware in branding products that in China the colour grey is associated with 'inexpensive' while in US it is associated with 'expensive'. On the other hand, the colour brown in China is associated with 'good-tasting' and in US with 'inexpensive' [5]. The way colours acquire a given conventional relationship with their referent will need a meticulous investigation of the history of its cultural determinants. For the present study, the research question was limited to test whether in a well-defined social context of university undergraduate students conventional relationships are naturally present by examining colour associations that students make with words extracted from their undergraduate prospectus. If conventional relationships exist they will be based on word-colour association consensus.

EXPERIMENTAL

Participants: A convenience sample of 85 participants, 72 females (mean age = 20.75, SD = 3.42) and 13 males (mean age= 21.15, SD = 2.27) studying Psychology (N=29); Fashion Media and Marketing (N=10); Event Management (N=36); Business Management (N=6); Drama and Event Management (N=3) and English Language (N=1). The experiment was approved by the University of Winchester Ethic Board.

Material and procedure: The response sheet consisted in 9 coloured rectangles and a list of 145 words (see Figure 1). Colours were selected from the NCS colour wheel (four cardinal colours + purple and 4 intermediate colours) and the closest visual match with sample from the Pantone fan deck was used for printing. Words were collected from the University of Winchester 2015-16 undergraduate prospectus which included 51,502 tokens (all word occurrences) from which 3930 types (i.e., word) were extracted leading to a final selection of 145 words based the word frequency and their relevance concerning the University activities and values. Students were invited to fill out the response sheets at their own pace after their usual lecture.

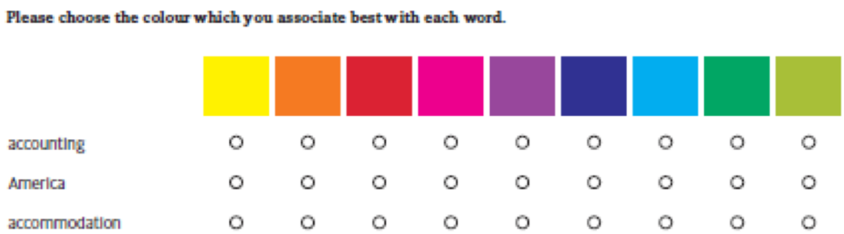
Please choose the colour which you associate best with each word.
accounting
America
accommodation

Figure 1: Three first items of the word-colour association response sheet.

RESULTS AND DISCUSSION

A frequency table with a total of 12,139 (186 missing data) data points provided an initial picture of the word-colour associations. The overall frequency selection for each colour and the word-colour associations selected by more than 40% of the respondents are reported in table 1. Dark-blue is the most frequently selected colour, followed by yellow, red, orange, purple, light blue, dark green, pink and light green. 'Youth', 'young' and 'children' are most frequently associated with yellow. 'Professional', 'master degree', 'industry', 'finance', 'enterprise', 'entrepreneurship', 'employment', 'business management', 'business' and 'accounting' are most frequently associated with dark-blue. 'Geography', 'field trips', 'field work' and 'environment' are most frequently associated with dark green. 'Fashion', 'dance' and 'choreography' are most frequently associated with pink and 'criminology', 'America' and 'impact' with red. Finally, 'creative writing' is most frequently associated with orange and 'knowledge' with purple. Light green and light blue do not exhibit any particularly high frequency of associations. Although the unbalanced male/female ratio (1/5.5) suggests caution in interpreting these data, gender differences were noted in case of 'creative writing-orange' and 'knowledge-purple' where high frequency selections were exclusively observed in men. Likewise, 'master degree', 'finance' and 'industry' were more frequently associated with red in men than with dark-blue as it was for women.

To further investigate the relationship between the two nominal variables 'words' and 'colours' a correspondence analysis (CA) was carried out. The analysis indicated that three dimensions could account for 78% of the variance with a significant relationship between the two variables (chi-square (1152) = 5862, $p<0.001$). Dimension 1 (D1) accounted for 35% of the variance opposing dark-green to pink while dimension 2 (D2) accounting for 28% singled out red and dark blue. The third dimension (D3) accounting for 12% of the variance (not shown) dissociated pink from yellow. When both words and colours are plotted on a biplot (Figure 2), words clustered on the green pole correspond to 'environment', 'field trips', 'fieldwork', 'geography' and 'sustainable' and words clustered on the pink pole are 'dance', 'fashion', 'young/youth/children', 'unique', 'creative/creativity', 'friendly', 'choreography', semantic categories for this dimension could be identified as 'natural environment' vs 'youth and creativity'.

Along the second dimension, words are clustered around red and blue colours. These include 'America', 'business', 'finance', 'employment', 'work', 'graduation'. The word cluster at the other side of the dimension is not clearly organised around a colour and correspond to 'peace', 'spirituality', 'freedom' and 'volunteering'. Semantic categories for D2 could be described as 'professional responsibilities' versus 'ethical values'. The third dimension (not shown) opposes yellow to pink and dissociates orange from purple. Words clustered around pink correspond to 'choreography', 'performance', 'desirable', 'gender' and 'dance' and those clustered around yellow correspond to 'children/youth/young', 'christian', 'christian foundation' and 'spirituality'. The semantic categories could be described as 'performing art' and 'youth and spirituality - ethical values'.

Table 1: Overall frequency selection (in percentage) for each colour and word-colour associations selected by more than 40% for females (f) and males (m). Colour code: Frequencies below 11% (which correspond to the frequency if colours are randomly selected) are coded in blue tint, and high frequencies in red tint.

		dark blue	dark green	light blue	light green	orange	pink	purple	red	yellow
Total (%)		**16.4**	**8.4**	**9.5**	**6.4**	**10.8**	**8.3**	**10.6**	**13.9**	**14.1**
young	f	1.39	0.00	5.56	11.11	6.94	13.89	5.56	5.56	50.00
	m	0.00	15.38	15.38	0.00	15.38	7.69	0.00	7.69	38.46
youth	f	1.39	1.39	6.94	8.33	22.22	13.89	2.78	2.78	40.28
	m	7.69	7.69	7.69	7.69	7.69	7.69	0.00	15.38	38.46
children	f	4.17	2.78	4.17	5.56	18.06	9.72	2.78	1.39	51.39
	m	23.08	15.38	0.00	7.69	15.38	7.69	0.00	7.69	23.08
professional	f	45.83	2.78	5.56	2.78	1.39	1.39	12.50	19.44	4.17
	m	23.08	0.00	23.08	0.00	0.00	15.38	7.69	23.08	0.00
masters degrees	f	47.22	4.17	6.94	2.78	4.17	2.78	6.94	13.89	11.11
	m	15.38	7.69	15.38	0.00	0.00	7.69	15.38	23.08	15.38
industry	f	55.56	5.56	6.94	0.00	8.33	0.00	4.17	8.33	9.72
	m	15.38	15.38	7.69	7.69	0.00	15.38	0.00	38.46	0.00
finance	f	45.83	9.72	2.78	1.39	4.17	1.39	6.94	19.44	5.56
	m	7.69	0.00	23.08	0.00	0.00	15.38	23.08	30.77	0.00
enterprise	f	19.44	8.33	9.72	6.94	15.28	4.17	8.33	5.56	22.22
	m	53.85	0.00	0.00	0.00	7.69	0.00	0.00	23.08	15.38
entrepreneurship	f	23.61	12.50	8.33	8.33	9.72	2.78	15.28	11.11	8.33
	m	46.15	15.38	0.00	0.00	7.69	0.00	15.38	7.69	7.69
employment	f	40.28	9.72	5.56	1.39	9.72	1.39	6.94	13.89	6.94
	m	30.77	0.00	7.69	7.69	7.69	7.69	7.69	23.08	7.69
business management	f	51.39	4.17	11.11	1.39	6.94	5.56	2.78	12.50	4.17
	m	46.15	0.00	15.38	0.00	0.00	0.00	15.38	23.08	0.00
business	f	47.22	2.78	6.94	0.00	9.72	5.56	6.94	18.06	2.78
	m	30.77	0.00	15.38	15.38	7.69	7.69	0.00	23.08	0.00
accounting	f	47.95	10.96	10.96	2.74	2.74	2.74	0.00	15.07	5.48
	m	23.08	0.00	30.77	7.69	0.00	7.69	15.38	15.38	0.00
geography	f	5.56	59.72	2.78	13.89	1.39	2.78	2.78	5.56	2.78
	m	0.00	46.15	7.69	0.00	7.69	7.69	0.0%	15.38	15.38
field trips	f	1.39	54.17	5.56	27.78	1.39	1.39	0.00	1.39	6.94
	m	0.00	53.85	0.00	15.38	7.69	0.00	7.69	7.69	7.69
fieldwork	f	8.33	48.61	2.78	27.78	4.17	0.00	0.00	2.78	4.17
	m	15.38	38.46	0.00	23.08	7.69	0.00	7.69	7.69	0.00
environment	f	2.78	50.00	5.56	29.17	4.17	0.00	0.00	1.39	2.78
	m	7.69	46.15	7.69	15.38	0.00	0.00	7.69	0.00	7.69
fashion	f	4.11	2.74	1.37	2.74	1.37	53.42	21.92	9.59	2.74
	m	7.69	0.00	7.69	0.00	0.00	38.46	15.38	23.08	7.69
dance	f	2.78	0.00	4.17	2.78	8.33	33.33	26.39	2.78	18.06
	m	0.00	7.69	7.69	0.00	7.69	61.54	7.69	0.00	7.69
choreography	f	5.56	0.00	6.94	2.78	8.33	22.22	23.61	8.33	19.44
	m	0.00	7.69	15.38	0.00	15.38	46.15	7.69	0.00	7.69
criminology	f	19.44	2.78	2.78	1.39	12.50	2.78	6.94	47.22	4.17
	m	7.69	7.69	15.38	0.00	7.69	7.69	15.38	38.46	0.00
America	f	9.59	1.37	6.85	1.37	0.00	0.00	1.37	73.97	5.48
	m	15.38	0.00	38.46	0.00	0.00	0.00	0.00	46.15	0.00
impact	f	15.28	9.72	5.56	2.78	12.50	5.56	15.28	23.61	8.33
	m	0.00	0.00	0.00	7.69	0.00	15.38	7.69	69.23	0.00
creative writing	f	4.17	4.17	6.94	4.17	20.83	15.28	9.72	12.50	18.06
	m	0.00	0.00	15.38	0.00	53.85	0.00	7.69	7.69	15.38
knowledge	f	27.78	6.94	2.78	4.17	5.56	2.78	12.50	19.44	13.89
	m	7.69	0.00	15.38	0.00	7.69	0.00	46.15	15.38	7.69

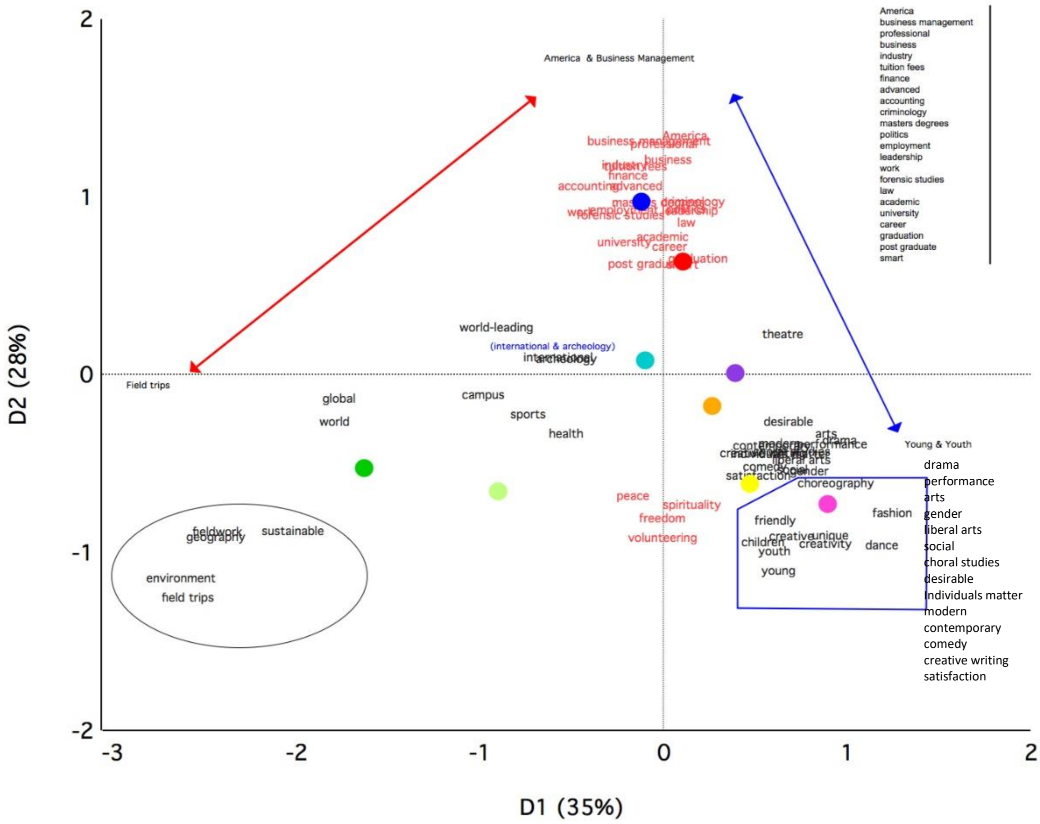

Figure 2: Biplot representing the two first dimensions with word-colour associations. Words and colour proximities reflect the strength of their associations. Words in tight cluster are listed onside for legibility.

CONCLUSIONS

Consensus obtained in word-colour associations revealed an underlying structure for which words in the two first dimensions clustered around three colour poles of 'green', 'red and blue' and 'yellow and pink'. These poles were associated to three semantic categories described as 'natural environment', 'professional responsibilities' and 'youth and creativity'. A fourth semantic category identified as 'ethical values' was not clearly associated to a colour and a third dimension point towards a distinction between 'performing art' and 'youth and spirituality / ethical values'. The emergence of a structure is indicative of shared word-colour associations in a given corpus of words, here a University undergraduate prospectus. These associations are prone to change with context [6], but possibly present in any socio-cultural environments reflecting the fact that colour-meaning emerges from intersubjectivity and cultural sharing.

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Colour influence in the favelas requalification process: Heliópolis case study

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ABSTRACT
Colour in the architecture contributes to the relationship with the environment because it can provide physical and psychological comfort, clarity of communication, aesthetic affirmation, identity, spatial orientation, typological, morphological and historical adequacy; therefore, it is a privileged tool to transform. Certain interventions have applied vibrant colours to the façades of some of Brazil's major favelas, using colours as a prominent feature of the grey landscape. In the light of the above, this paper presents the case study of the project developed by the Brazilian architect Ruy Ohtake, who voluntarily conceived the project for the painting of two hundred and seventy-eight façades of the favela of Heliópolis, in the city of São Paulo, Brazil, in 2003. The article presents the scientific and media views on this type of intervention in urban space and reports some of the developments and benefits of this project for the community.

Keywords: *Colour in the built environment, favelas requalification process, Heliópolis, Ruy Ohtake, Cultural identity*

INTRODUCTION
The favela is a place where colours and textures are associated with the apparent coating materials of brick, plaster and concrete, with the predominance of different earthy tones ranging from brown to grey. These colours and textures camouflaged or highlighted by light integrate the landscape marked by the improvisation and the temporary dwelling that ended up becoming definitive.

This is the scenario that transformed the favelas into a stereotype of poverty and violence composed of grey and dark tones. The colours, textures and forms combine in a non-hierarchical way in most favelas, overflowing the aesthetics marked by the lack of space orientation and the materiality of the buildings adapted to the scale of small alleys, alleys, tortuous and steep paths.

THEORY

According to Hacher (1987), colour should not be explained simply as a physical phenomenon. For, knowledge about colour was not able to be exhausted despite advances in many areas of knowledge such as physiology, psychology, optics and physics (DURÃO 2000 apud Durão, 2005). "Colour perception varies according to the context in which it is found (...)" (Durão, 2005, p.36). Just as semiotics is closer to the interpretation of meaning, "the interpretation of visual information is highly subjective" (Moreira da Silva, 2013).

In the specific case of the favelas, the complex psychophysiological interactions of colours transcend the relationship between form/background, compositions, surfaces, light and distance. Moreover, the perception of apparent colours and materials, predominant in the Brazilian favelas, are associated both with the context of violence, poverty and improvisation that demarcated these places as lack of identity and culture.

Colour in architecture contributes to the relationship with the environment because it can provide physical and psychological comfort, communication clarity, aesthetic affirmation, identity, spatial orientation, typological, morphological and historical adequacy, therefore, it is a privileged tool to transform (Durão, 2013).

In this sense, it is observed that some interventions have applied vibrant colours on the façades of some of the main favelas of Brazil, using colours as a highlighted element of the grey landscape. This type of intervention had great repercussion with the project of the Brazilian architect Ruy Ohtake, who voluntarily conceived the project for the painting of two hundred and seventy-eight façades of the favela of Heliópolis, in the city of São Paulo in 2003. This project which had the active participation of the community was initially executed without the support of the public power, only with the donation of private companies and it drew attention to the situation of the favelas.

This type of intervention, with the use of colours on façades, has had repercussions of two opposing ways in the media and in the scientific means. Some interpretations highlight the influence of colours on the community's identity-building process, leading to a more positive image of the favelas and contributing to the improvement of the community self-esteem (Kosmala & Imas, 2012), while other interpretations consider the interventions as a romantic and cosmetic camouflage of the ignored reality (Rahman, 2014) encouraging tourism of poverty (Rolfes, 2010), without significant repercussions for the improvement of the living conditions of their inhabitants.

CASE STUDY: THE CHROMATIC PROJECT OF THE FAVELA OF HELIÓPOLIS

Heliopolis is the largest favela in São Paulo and the second largest in Latin America. It has around seventy thousand inhabitants and "open the contradictions of the city: opulence and misery, solidarity and indifference" (Melendez, 2012, 55). The chromatic project carried out by the Brazilian architect Ruy Ohtake for the favela of Heliópolis was motivated by the community residents who requested the architect's help in 2003, a misunderstanding caused by an interview was the opportunity for Ruy to accept the challenge proposed by the community leader of the favela to make it less ugly.

Without financial resources, at first, the architect who has as main characteristic features of his work the use of curves and vibrant colours, proposed a chromatic intervention project with the painting of the façades of three streets selected by the residents themselves. The voluntary project was made possible by the influence of the architect who obtained the donation of paints from a manufacturing company and by the active participation of the community in the execution of the painting. In this project, two hundred and seventy-eight façades were painted (Bosco, 2011).

The chromatic project titled by Ohtake as "Cultural Identity of Heliopolis" (Melendez, 2012), counted on the active participation of the community and all the residents made the choice of colour that should predominate on the façade of their houses. Six vibrant colours that ranged from bright yellows to deep purples made up a range of choice for the locals. From the predominant colours selected for each house, Ohtake developed a project in which he made the combination of the predominant colours in each house, in different shades (from lightest to darkest) for composition of the façades and the contour of doors and windows. The project occupies three streets of the favela that were reformed and painted in order to clarify the space occupied by each of the houses that were built without spacing between them. Each façade received a predominant colour, with horizontal or vertical stripes that present variations of nuance. From the chromatic intervention and the reform of the façades the view of the streets was flooded by a river of colour, abandoning the sombre landscape of unfinished brick houses (Wade, 2005).

Figure 1: Façades of the favela of Heliópolis before the painting and the final result after the colours application. Source: Ruy Ohtake (2012).

According to Silva (2004), the colours of the façades of the houses of Heliópolis cannot be considered as a cosmetic camouflage of the problems that involve the community. According to Ohtake, the idea of the project was to create a composition with mixed tones that reflected the solidarity found in the community of Heliópolis, the vibrant colours would symbolize the inhabitants' claim for urban inclusion (Silva, 2004). The architect recalls that from the outset the project was a great challenge, but he always believed in the social function of beauty, and this was the way he found to implement his belief (Wade, 2005).

In continuity to the project, the community and the architect mobilized so that Heliópolis could create a cultural identity beyond the painting of the façades. For that, they planned together projects of artistic education, library, computer science school, cinema, exhibition gallery, cultural centre and a fair. These projects were made possible with the support of private and professional companies that had already worked with Ohtake on other projects. At the time, the architect already envisioned seeking support from the public power to expand the project to other streets of Heliopolis. (Silva, 2004).

Several other projects were carried out by the architect under the so-called Heliopolis Cultural Education Pole, located in an area of 35,000 m² which includes: a technical vocational school, a cultural centre, a library, a sports centre and a workshop space (Longman, 2010). The implantation of the polo was an unfolding of the close relationship that the architect established with the population, the urban, architectural, cultural, and even political issues of Heliópolis (Melendez, 2012).

RESULTS AND DISCUSSION

Due to the great repercussion obtained in the media by the chromatic work carried out in the favela of Heliópolis, this intervention became a means for more expressive social changes. The project stimulated questionings and new perceptions about the favela through subjective visual interpretations, allowing the indication of senses and meanings of this work. The violence and contradictions of the favela have not been expurgated, but the intervention has promoted a path of social change, a platform that creates space for questions about perceptions and the general imaginary about the favela and its inhabitants and, at the same time, colours opened up an important space for the community to become visible.

According to Kosmala and Imas (2012), the favelas inhabitants strive to improve their living conditions and with ongoing pacification processes, they continue to coexist in their invisible paths, between constructed walls and stigmatized perceptions. However, in Heliopolis, the chromatic project expanded and managed to show the world its conception of transformation through colours.

Currently Ruy Ohtake has five projects in the permanent collection of the Centre Pompidou Museum in Paris and among them is the chromatic project of Heliópolis, a source of pride for the community. In an interview with Bosco (2011), Ohtake reveals his preference for vibrant colours for architecture instead of "white architecture". For him, the Brazilian cities were losing their colour. At the exhibition the architect made a point of showing his preference for the strong colours he calls “colours of compromising”.

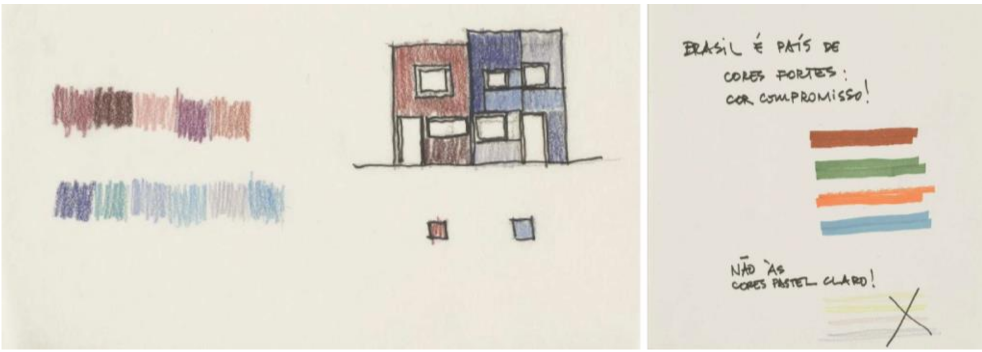

Figure 2: Ruy Ohtake’s colour studies (2004). Source: Centre Pompidou Museum – Paris.

The willingness of the community to collaborate in a participatory and collective way for the execution of the project, also demonstrates the social character of this urban intervention that, despite the ephemerality of the vivid colours, promoted the experience of a historical moment for the community and the recovery of the self-esteem of the residents. According to Silva (2004), the partnerships won by the architect with the Suvinil paints company enabled the training and payment of eight favela painters who were unemployed.

Testimonials from the inhabitants of Heliópolis demonstrate how the use of colours has been able to revive self-esteem and hope for even more expressive improvements. A resident who grew up in Heliopolis and lives outside the area that was painted, Mr. Barbosa, stated in his testimony that the residents' desire is to expand this project to the entire favela because people love their painted houses. According to João Miranda, the president of UNAS (Nuclei Union, Associations and

Societies of Heliopolis and São João Clímaco), the residents are mobilizing themselves to improve the sidewalks of the painted streets (Silva, 2004). According to this resident, who would not want to live in a beautiful home? For him, the residents of Heliopolis want the same things as all the others (Wade, 2005). Aparecida Crepaldi, a 25-year-old resident of Heliópolis, says "this is the first time that the façade of her home has been finished. At the end, the house was exactly the way I asked for" (Silva, 2004).

CONCLUSION

In the case of Heliopolis, colour was an important driver to promote a participatory process for requalification of the favela, as shown in the presented case. When the colours are applied to the walls, windows and doors of the façades, architecture takes another form, it becomes unique. Colours reflect and highlight other contexts and characteristics of these spaces, such as the great sense of community, cooperation and joy among the residents of these places. Therefore, it is believed that the use of colour can help to undo the stereotype of sad, grey and dark shantytowns and bring the attention of local authorities to more complex problems. Therefore, colour as a prominent element of the landscape in Heliopolis has become an important laboratory on the effects of the urban-scale colour change on the favela community.

ACKNOWLEDGEMENTS

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colour & human comfort

Colour in Architecture and the writings of Pseudo- Dionysius, The Areopagite

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ABSTRACT

This paper aims to study colour in architecture, based on texts that would have been written by a Syrian mystic of the fifth century who used to conceal his identity under the alias of Dionysius the Areopagite, a council member of the Athenian Areopagus law court and follower of the apostle Paul, as mentioned in the book of Acts in the Bible (Acts 17:34). Dionysius acquired a nearly apostolic authority which gave enormous credibility to his writings in the Middle Age and the Renaissance. This work deals with Dionysius's concepts of colour, regarding the writings of Goethe and Plato, particularly the ones found in Timaeus, Menon, and Socrates; aiming at applying them in a study of the chromatic perceptive processes of architecture. It intends to present concepts that can contribute to a better understanding of some historic approaches of those processes and the relation among harmony, chromatic diversity and completeness. It also intends to analyse aspects, regarding colours, which could have influenced Gothic constructions, particularly the abbey of Saint-Dennis in France, as well as the work of Abbot Suger.

Keywords: *colour in architecture, Dionysius The Areopagita, Abbey of Saint Denis.*

DIONYSIUS, THE AREOPAGITE AND THE CORPUS DIONYSIACUM

> "And Dionysius with so great desire to contemplate these orders set himself, he named them and distinguished them as I do. But Gregory afterwards dissented from him; wherefore, as soon as he unclosed his eyes within this heaven, he at himself did smile. And if so much of secret truth a mortal proffered on earth, I would not have thee marvel, for he who saw it here revealed it to him, with much more of the truth about these circles." (DANTE, Paradise, Canto XXVIII :407)

It may seem slightly anachronic these days, as René Roque states in the introduction of The Complete Works, to underline the present-day-value of Pseudo-Dionysius works, because “author and treatises (are) enigmatic, hard to understand, (and) involved in a historical and doctrinal context so far removed from ours” (ROQUES, in PSEUDO-DIONYSIUS, 1987:5). However, the influence of his writings can be felt in the work of many scholars, including his influence upon colours, to date.

The Corpus Dionysiacum, as it is known, consists of four treatises: The Divine Names, The Mystical Theology, The Celestial Hierarchy, The Ecclesiastical Hierarchy and ten letters. The question is: who really wrote these texts? The authorship of the texts is, as a rule, attributed to Dionysius, the Areopagite, a council member of the Athenian Areopagus law court and a follower of the apostle Paul, as mentioned in the book of Acts in the Bible (Acts 17:34). Their importance, especially in the Middle Ages, was enormous and many even attribute them to the apostle Paul himself, who would have handed them down to Dionysius, as it is implied in Dante Alighieri’s The Divine Comedy. However, they were most likely written by a Syrian mystic of the fifth century who used to conceal his identity under the alias of Dionysius, due to the influences and similarities found in the texts of philosophers such as Plotinus (204/5-270), Iamblichus (250-330), and Proclus (410/412-485).

According to Ernst Benz, the theology of colour found in Areopagite, is directly connected with his Theology of Light. God is the primeval light which is inaccessible- “The Divine Darkness”. No one can look upon The Primeval Divine Light itself. God “dwells in unapproachable light, whom no man has ever seen or can see”, for neither is it without danger to gaze upon the glorious rays of the Sun with weak eyes”. The primeval light reveals itself only in that, corresponding to the powers of comprehension of the creatures of the lower spheres, it garbs itself in envelopments, symbols, analogies and images. Colours are the veils of the divine primeval light in its descent and its radiation into the lower worlds. The purpose of this hierarchical structure is the initiate’s greatest possible similitude to, and becoming one with, God. (BENZ, 1988)

The spiritual interpretation of the colours is accordingly repeated at the church level. The worldly church is similar and corresponds to the celestial church above. The sacraments, symbols, and ceremonies reflect the order of the church above and the colours of the church correspond to the colours of the angelical world. This is valid not only for the liturgical vestments but also for the icons painted on church walls.

Symbols are used as a way of transforming the immaterial into material, the human into what is divine; as a way of bringing the transcendental to our level and, at the same time, of keeping it away from the reach of the profane.

> “We see our human hierarchy, on the other hand, as our nature allows, pluralized in a great variety of perceptible symbols lifting upward hierarchically until we are brought as far as we can be into the unity of divinization.” (PSEUDO-DIONYSIUS, 1987:197)

Dionysius deals with the notion of deification or Theosis, the search for The Beauty of The Unity and Harmony of The Whole manifested in everything we see.

> “In the domain of perceptible images, the artist keeps an eye constantly on the original and never allows himself to be sidetracked or to have his attention divided by any other visible object. If he does this, then one may presume to say that whatever the object which he wishes to depict he will, so to speak, produce a second

> one, so that one entity can be taken for the other, though in essence they are actually different. It is thus with those artists who love beauty in the mind. The concentration and the persistence of their contemplation of this fragrant, secret beauty enables them to produce an exact likeness of God." (PSEUDO-DIONYSIUS, 1987:226)

Fundamentally, in his work, all reality consists of hierarchical levels and a triad. Within each hierarchical level there is a ternary structure (three levels with three other subdivisions) and functions in all three of them: the first, the union and perfection; the second, the enlightenment; and the third, the purification.

LIGHT AND COLOUR ACCORDING TO PLATO

Plato, in Timaeus, in a dialogue with Socrates, describes what he calls "the rational theory of colours". To him, the vision, as well as the other human senses, would be associated with one of the elements of nature which, in this case, would be the fire.

Colour and light coalesce and represent the knowledge which is in all things and constitutes the human being. The meeting of the "knowledge" contained in colours, when they reach the retina, with the knowledge that constitutes men and with the fire sent forth through their eyes, makes up the image that they see. This relationship among light, colour, and knowledge, the last being a manifestation of the divine, can also be observed in the work of the Pseudo-Dionysius and in the Theology of Light.

> "Every good endowment and every perfect gift is from above, coming down from the Father of lights." But there is something more. Inspired by the Father, each procession of the Light spread itself generously toward us back to oneness and deifying simplicity of the Father who gathers us in. For, as the sacred Word says, from him and to him are all things." (PSEUDO-DIONYSIUS, 1987:145)

This same idea can be found in the writings of Goethe when in his book Theory of Colours he mentions a citation attributed to Plotinus, one of the most important philosophers of Neoplatonism.

> "If the eyes were not sunny, how could we perceive light? If God's own strength lived not in us, how could we delight in Divine things?" (GOETHE, 1978:53)

In another dialogue, Plato describes a conversation between Socrates and Meno about virtue in which he defines shape and colour:

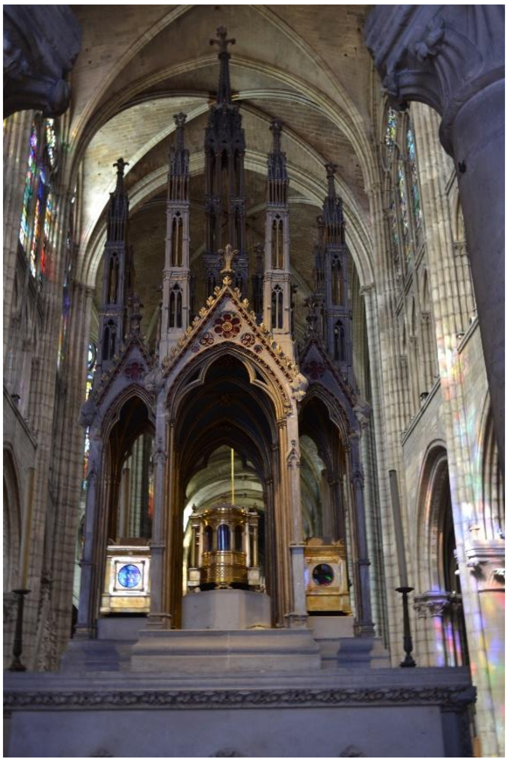
> "Figure is the only thing which always follows colour" (PLATO, 1937:354)

> "I define figure to be that in which the solid ends; or, more concisely, the limit of solid"...."colour is an effluence of form, commensurate with sight, and palpable to sense." (PLATO, 1937:355)

Later, in Theaetetus, Plato returns to the subject of colour, reporting the dialogues of Socrates with Theaetetus and Theodorus on knowledge and wisdom. Among the aspects covered in the text, Socrates discusses the relationship between knowledge and perception, citing Pythagoras, to whom man is the measure of all things, of the existence of all things that exist and the non-existence of the things that do not exist. To Socrates, all things are indeed in motion and nothing is motionless. We do not perceive sensible things through the mind, but with the mind, not with the senses, but through the senses. Senses differ from each other and do not have objects in common.

THEOLOGY OF COLOUR AND ARCHITECTURE: THE GOTHIC AND ABBOT SUGER

Georges Duby wrote the following about the work of Abbot Suger on the construction of the monastery of St. Dennis, between 1135 and 1144: he creates the monument as a theological piece of work, based on the writings of the patron of the abbey of Saint Denis or, as it was believed, Dionysius the Areopagite. The central idea is “God is Light”. Light, “created or uncreated, in which participates every creature that receives and transmits its illumination, according to their capacity or place occupied in the scale of being.” (DUBY, 1979:105)



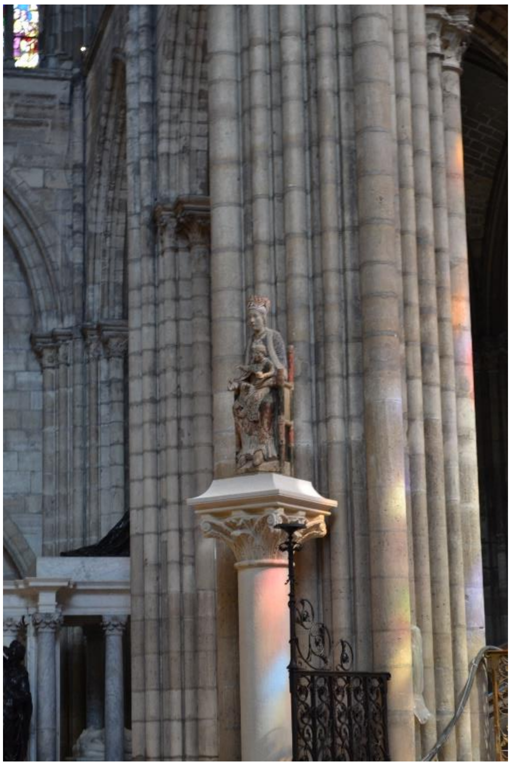


Figure 1,2: Abbey of Saint Denis, interior (photos of the author).

The work of Suger on St. Dennis is based on Dionysius’s hierarchies and the celebration of the unity of the universe. Differently from the Romanesque style, Suger opens spans, allows light to come through, unbroken, unifying, cohesive. The hierarchies are revealed by the variation in lighting, the light of the setting sun that penetrates through the concave of the three portals and by the rosette above them, illuminating the three high chapels dedicated to the celestial hierarchies.

The colours of the gems acquire a symbolic value related to the Christian virtues:

> “when enthralled by the enchantment of the beauty of God’s home, the seduction of the multicoloured gems leads me to ponder, transforming the material into the immaterial, on the diversity of the sacred virtues, then it seems to me that I see myself residing as in reality in a strange region of the universe that has never existed before either in the mud of earth or in the purity of heaven and, by the grace of God, I can be transported from here to the highest world, in an anagogic fashion.” (DUBY, 1979:108)

About this topic, Dionysius wrote:

> "With regard to multicoloured stones, these must be taken to work symbolically as follows: white for light, red for fire, yellow for gold, green for youthful vitality" (PSEUDO-DIONYSIUS, 1987:198)

In order to dignify the light of the Lord, as Duby states, he commissioned the most luminous windows so as to allow the irisations of the amethyst or the rubies and reproduce the colours of the heavenly virtues. The impact of the innovations in St. Dennis can be identified in several other gothic cathedrals such as Chartres, Burges, and Angers.

CONCLUSION

John Gage, in *Colour and Meaning*, highlights the influence of concepts developed by Dionysius, not only on the abbey of Saint Dennis, which can be felt throughout the Gothic, particularly on the symbolic relations of colours, but also on the studies of Lorenzo Ghiberti in the XV century and on the relations of the humanists with light. (GAGE, 1999)

One of the aspects found in several authors, particularly in Goethe and in some experts in environmental chromatic perception, is the concept of harmony and the ideas of complementarity and unity. The harmony manifested in the search for unity through the chromatic diversity or chromatic completeness, as something intrinsic to humans. Colours meaning the light to the weak human eyes which cannot look directly into the sun, the source.

A theory of harmony based on the idea of the complementary colour can be found in Newton and Chevreul's *On the law of Simultaneous Contrast of Colours* (1839).

> "When in this completeness the elements of which it is composed are still appreciable by the eye, the result is justly called harmony". (GOETHE, 1978:28)

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Colour and Authenticity

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ABSTRACT

With the aim of searching for the authenticity of colour in public space, we confront historical descriptions and technical questions that equate the principles of intervention over time. However, different information hampers a definitive conclusion, as it happens with the statue of *D. José I*, in *Terreiro do Paço*, Lisbon. The work of the investigation concerns the confrontation of gathered information and evaluates the purpose of the intervention: Which was the initial colour of the statue of D. José I? Would the aim be the cleaning of the statue or was it to create expectations on the discovery of its initial colour as something innovative? Is the occurrence in the appearance or in the composition of the alloy? As the result of the analysis is dominantly focused on the statue and, by extension, in the colour of the buildings placed in *Terreiro do Paço*, there's an equation of technics that result from authenticity, crossing aesthetical criteria, the used technics and the combination of these aspects among themselves.

Keywords: *authenticity, patina, initial colour, metamorphose, cleaning*

INTRODUCTION

When we refer to the modification of colour as times passes by, we question the implications of its impact on the reading of the objects: its physical characteristics (relations of colour with the support), its chemical characteristics (chromatic qualities and their instability) and its relation with light (colours qualities caused by light). One can equate, complementarily, the effect caused by pollution, abrasiveness and dirtiness. Being these factors central in the variation of colours in objects and buildings, how can we characterize the authenticity of colours when mentioned in sculpture and in architecture? The authenticity has to have in mind historical, aesthetical and materials aspects, along with the relations with the surrounding space.

These questions must consider cultural references along with the type of interventions intended to be done. In this analysis, we refer to the statue of *D. José I*, in *Terreiro do Paço*, Lisbon, where it is still needed to equate the importance of the patina in the sculpture. This question was determined in the beginning by the author, sculptor *Machado de Castro*, in 1774, year of the foundry of the statue, in order to achieve the colouration intended, reinforcing the protection against the abrasiveness of the brackish water of the river. There's also another patina that appears as a consequence of the behaving of the material over time.

Goethe used to say refer that the degradation of colours is a sign of chemical colours. Thereby, it is necessary to equate, a priori, the chemical behaviour of materials and of pigments under the action of time and light, and take into account the materials, the place where the object is located, as well as the effect of the abrasives to which it may be subjected.

In this Square, we also question the colour of the buildings that configure the public space: its authenticity, meaning and impact that the colour has and its alteration, in the various interventions that were made over time. The option for the colour of the Square derived from a political, aesthetical justification that was submitted to public surveys to choose the colour of the majority. An historical investigation reveals that the initial colour was ochre yellow- the same that is presented nowadays (Figure 1)-, but it also has been painted as water-green and old pink. Olive green was the colour that the Lisbon painter *Carlos Botelho*, suggested for *Terreiro do Paço*.

Figure 1: Colour of *Terreiro do Paço* in 2018: Photography by *Rui Barreiros Duarte*, 2018.

THEORY

The existence of different chromatic records of *Terreiro do Paço* over time, clarifies the importance of colour and of historical investigation in the explanation of decisions.

Its authenticity stems from the referred factors, so we are not referring to what is genuine on the colour of this Lisbon urban space that has been changing over time.

The facts are just descriptive and not conclusive, the value judgements belong to the aesthetic or political dominance and it mixtures with populism.

There is talk of consensus but there isn't any scientific determinant that headed the interventions, what its meaning was, or what was the composition of the plasters. Nevertheless, there is a constant: the colours and shades of the different façades in the Square are always the same, conferring union to the whole.

When a “bronze sculpture” is built, the intended effect occurs from the patina applied on the material in order to protect it and stabilize it over time. The shade may be the desired one but it must be controlled and cleaned in a systematic way and, therefore, monitoring must exist. There are a number of shades and colours of patinas at the disposal of the author’s artistic desire, factor that can be combined with the material’s behaviour on the action of time.

Figure 2: Statue of *D. José I*, in *Terreiro do Paço*, Lisbon: Photography by Rui Barreiros Duarte, 2018.

This is a completely different aspect than the central question regarding the intervention of the statue of *D. José I*: to obtain the original colour means to know the colour of the metallic alloy: if it was green, black or yellow. Nevertheless, the question should have been raised in relation to the initial option of the patina (Figure 2), there being another patina as consequence of the corrosion process. The black occurs “due to the accumulation of oxides and the deposition of dust and suspended fine dust in the atmosphere. This patina is very homogeneous and adherent, has protective characteristics and will remain for many years if the environment is not polluted.” (Fontinha & Salta, 2008, p.88) TL. The green patina occurs from the fact that "mainly sulphates and / or copper chlorides are formed, giving origin to the appearance of patinas of green colour in sculpture areas where it is easier for the aggressive agents to access" (Fontinha & Salta, 2008, p.88) TL.

The action of time over matter also gives plastic qualities from which effects are equated right from the start. Thus, the control must be put on its process of ageing or stabilization and not on the initial colour of the material. Yet there is always randomness in the process. There have been many readings regarding the colour of the equestrian statue of *D. José I* over time. Descriptions of visual memories refer to the black, gold or green horse but it is always the same horse, “*Gentil*”. Thus, there’s a colour imprecision: the popular imagery describes it as gold whilst in some English travellers’ records it is black and green due to the action of time.

António Costa, as Lisbon Mayor, on a visit to the civil work referred that the intervention “will take away the green patina that the king and horse have today (...)” (Canelas & Rocha, 2012) TL.

The photographs of the cleaning of the statue that register the WMF (World Monuments Fund) intervention, present a partially black colour on the eastern side due to the dirtiness, and on western side a green colour blurred by the sun.

José Ibérico Nogueira, from the Portugal WMF Association, who has recovered the statue, refers that the cleaning is a way of containing the chemical and mechanical process of degradation that accentuates the green patina.

Technically, the pathology analysis, made with a technique that crosses laser beams as a radiography, allows to detect the materials' behaviour, and that the cleaning is made with precision both in the stone plinth and in the statue, a set that was graphically registered.

Regarding the colour and composition of the metallic alloy, *Ibérico Nogueira* mentions that the speculations about the initial colour - that support the polemic of the theme - occur from the composition of the alloy. Due to the characteristics of the place, subjected to the abrasiveness, it is thought that the composition might be closer to the admiralty brass than to bronze, since this salinity-resistant material is much used by the Navy.

The Bronze has a symbolic roll which importance is reinforced by the big structural resistance, the lack of atmospheric corrosion, ease of casting, great finishing ability and the possibility of executing details (close to gold).

The scientific precision in terms of components is diverse. The imprecision on the alloy composition, occurs from the fact that there's no reliable register on the subject, questioning the description of the sculptor *Machado de Castro*, as the founder was the Lieutenant-Colonel *Bartolomeu da Costa* who became more important in the work.

"The romans discovered that the alloy was adequate to merge in lost wax and in works with details and finishes, it would be an alloy of 80% copper, 10% tin and 10% lead" (Manso, 2011, p.20) TL.

These are very important technical aspects that require in-depth studies and experts in this field.

In terms of authenticity one equates historical, aesthetic and artistic values arising from the relation of the artist with the artistic object produced, its appropriation by the public, as the attributed value emerges from the individual-object relation, apart from the quality of its foundation.

The colour of the statue derives from the composition of the alloy and the initial patina that was given to its protection, plus the levels of degradation that it suffered given the heterogeneity behaviour of the material that composed the alloy and its orientation.

We are facing historical and technical sources, the imprecision does not allow to overcome doubt, but we must consider the materials' behaviours and the results from the cleaning of the statue. In this intervention, the cleaning was technically detailed and according to the graphic records. The cleaning was also involved in a technical complexity, with a budget intervention of 490.000 euros, guaranteed by sponsorships.

Due to the collection of historical elements, "the first cleaning of the statue was made in 1926", this is, 151 years without cleaning at all. The second period without a cleaning was 86 years (until 2012).

The matter of the statue's need of has never arisen. Although 3.000 l of water were taken of its interior, of referring that the structure of the horse is made in iron, there have never been argued reasons of corrosion, stability handicaps, or defaults that needed to be corrected.

Nevertheless, if this information were rigorous, the iron would be corroded due to its contact with water for more than one century and a half and it would have reacted with the metallic alloy of the horse, a galvanic corrosion according to the Mendeleev's Periodic Table.

One must also register comparatively, that in Paris a lot of metallic sculptures are coated with gold leaves that, besides the symbolic aspects, avoid the corrosion caused by the surroundings. However, the galvanic corrosion stays in its interior caused by the action of the metallic alloys with the gold.

It is also referred that in the previous intervention (1983), 14 bullets were detected in the statue. Having been blown from a single jet, the possibility of entering water could have been made through the holes of the bullets. Nonetheless, when mentioning that in the intervention an "endoscopy" was made through a hole in the horse's belly, this means that it has not been covered since 1983.

From the Machado de Castro's study analysis for the sculpture of the horse in the statue of D. José I, it is verified that it represents a structure with the expression of wood that would correspond to the formwork lost inside the foundry. Thus, the metallic alloy has different thickness levels being the smaller located in the horse's belly.

CONCLUSION

When considering the importance of colour and its impact in the collective symbolic, one can identify the following questions in the urban space of *Terreiro do Paço*: the reasons evoked by the colour variations on the paintings of the buildings' façades were political, aesthetical and social.

All of those intend to justify its authenticity but they don't modify the qualities of space and environment. The authenticity occurs from the type of paint applied, having in consideration the quality of the supports.

The main question, which that led to the cleaning intervention of the Statue of *D. José I*, was the search for its initial colour (yellow, black, green), but with a good monitoring and adequate cleaning made over time, water and wax would have been sufficient.

The scientifically based methodology used refers to granulometric records but we are left without knowing the exact composition of the metallic alloy, as descriptions we had access to were diverse.

The question on the black that the statue presented is of two types: it occurs from its dirtiness - due to the fact there wasn't a necessary maintenance over time - or of the patina initially used, which is the most likely situation, based in scientific studies on this matter. Yet, we can also have a double opposite reading: the green could have been used as the initial patina and persisted as steps of the corrosion. Given the imprecisions, we are left with methodical doubt.

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"Edible" colour names: Cross-cultural comparison of Russian and English

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ABSTRACT

We explored differences between Russian and English languages in incidences of colour names related to food and edible substances. Colour names were elicited in a web-based psycholinguistic experiment with native speakers of Russian (N=713; 333 males) and English (N=272, 113 males). Colour samples (N=600) were approximately uniformly distributed in the Munsell Colour Solid. An unconstrained colour-naming method was employed. A refined dataset comprised 14,260 responses from Russian and 5,428 responses from English speakers. For each language dataset, we report the inventory of "edible" colour names, their frequency, and derivational productivity. We conclude that, along with the natural environment, the inventory of "edible" terms is language-specific and manifests culture-specific culinary worldview.

Keywords: *"edible" colour names, Russian, English, cross-cultural differences*

INTRODUCTION

In different languages a substantial number of secondary colour terms are derivatives from names of objects, whereby the colour term metonymically stands for the colour of the object in question. Among such colour terms, common are referents to objects relating to food and edible substances, such as fruits, berries, vegetables, nuts, spices, beverages etc. The choice of the prototypical colour referents apparently depends on their availability in the natural environment but is also influenced by culture, highly scripted and ritualized (e.g. Vasilevich *et al*. 2002; MacDonald and Mylonas 2010). In the present study we explored differences between Russian and English languages in incidences of colour names related to food and edible substances.

EXPERIMENTAL

Colour names were elicited in a web-based psycholinguistic experiment (Mylonas and MacDonald 2010; http://colournaming.com). Participants were native speakers of Russian (N=713; 333 males) and English (N=272, 113 males), all aged 16 years or older. Colour samples (N=600 in total) were fairly uniformly distributed in the Munsell Colour Solid. An unconstrained colour-naming method was employed. Russian speakers input their responses using a keyboard with the Cyrillic alphabet.

Responses of participants with colour vision abnormality, estimated by a colour-vision test, part of the program, were excluded. Also excluded were responses containing Russian basic colour term (BCT) *koričnevyj* 'brown' (originally derived from *korica* 'cinnamon'), as well as English BCT *orange*, since in the two modern languages meanings of both had emancipated from the original object referents. A refined dataset comprised 14,260 responses from Russian speakers and 5,428 responses from English speakers.

For each language dataset, estimated were the following linguistic measures:

(i) the list of "edible" categories and the inventory of colour names in each category;

(ii) frequency of each colour term's occurrence;

(iii) patterns and number of mono- and polylexemic descriptors derived from each "edible" object name (the term's derivational productivity).

RESULTS AND DISCUSSION

(i) The list of "edible" categories and the inventory of colour names in each category

Following MacDonald and Mylonas (2010), in both Russian and English data we focused on specific categories, such as "fruits", "vegetables", "berries", "fish" etc. (Table 1).

Category	Number of objects		Number of derivates		Percentage of cases	
	Ru	Eng	Ru	Eng	Ru	Eng
Fruits	12	11	41	57	1.68%	3.96%
Vegetables	9	6	44	12	2.49%	0.39%
Berries	8	8	31	15	1.58%	0.55%
Herbs	6	3	16	11	0.48%	0.63%
Sweets	6	14	14	31	0.32%	0.99%
Alcohol	5	5	29	17	2.23%	1.11%
Hot and soft drinks	5	3	11	7	0.17%	0.15%
Dairy products	4	2	17	2	0.23%	0.04%
Spices	4	3	16	9	0.54%	0.66%
Nuts	3	4	9	17	0.18%	1.16%
Cereals	1	4	1	4	0.01%	0.07%
Fish	1	1	8	11	0.11%	1.12%
Poultry /egg	1	2	1	7	0.01%	0.17%
Total	**65**	**66**	**238**	**200**	**10.03%**	**11.00%**

Table 1: Categories of "edible" objects referred to in Russian (Ru) and English (Eng) colour names.

Although the number of "edible" colour-term referents in both languages was similar, 65 in Russian and 66 in English (Table 1), the inventories varied substantially between the two sub-samples (Table 2). Notably, 28 referents offered by Russian respondents and 24 by English were "endemic" to either language, with differences being prominent in the "vegetables" and "sweets" categories.

Category	In both languages	Only in Russian	Only in English
Fruits	peach / *persik*, lime / *lajm*, lemon / *limon*, olive / *olivka*, plum / *sliva*, apricot / *abrikos*, apple / *âbloko*, tangerine / *mandarin*	*apel'sin* 'orange', *gruša* 'pear', *banan* 'banana', *granat* 'pomegranate'	melon, damson, citrus
Vegetables	pumpkin / *tykva*, tomato / *pomidor*, *tomat*, aubergine / *baklažan*	*salat* 'lettuce', *morkov'* 'carrot', *svëkla* 'beetroot', *kapusta* 'cabbage', *redis* 'radish'	pea, spinach
Berries	raspberry / *malina*, cherry, cerise / *višnâ*, blackberry / *eževika*, grape / *vinograd*, strawberry / *klubnika*, berry / *âgoda*	*brusnika* 'cowberry', *černika* 'blueberry'	goji berry
Herbs	mint / *mâta*	*zelen'* 'potherbs', *lipa* 'linden', *raps* 'rapeseed', *tabak* 'tobacco', *cikorij* 'chicory'	sage, lemongrass
Nuts	maroon / *kaštan*, pistachio / *fistaška*	*orekh* 'nut'	chestnut, hazel
Cereals	wheat / *pšenica*		corn, maize, oat
Spices	mustard / *gorčica*, saffron / *šafran*	*kurkuma* 'turmeric', *karri* 'curry'	chili pepper
Fish	salmon / *losos'*		
Poultry	egg shell / *âičnaâ skorlupa*		
Dairy products	yoghurt / *jogurt*, milk /*moloko*	*slivki* 'cream', *smetana* 'sour cream'	
Sweets	chocolate / *šokolad*, caramel / *karamel*, vanilla / *vanil'*, custard / *krem*, bubble gum / *žvačka*	*zefir* 'zephyr'	candy floss, toffee, sugar, biscuit, bisque, sherbet, honey, dough
Alcohol	bordeaux, claret / *bordovyj*, burgundy / *burgundskij* wine / *vino*	*burbon* 'bourbon', *šampan* 'champagne'	chartreuse
Hot and soft drinks	green tea / *zelënyj čaj*, water / *voda*	*kakao* 'cocoa', *kofe* 'coffee', *burda* 'slipslop'	juice

Table 2: Inventory of frequent "edible" referent objects: comparison of English and Russian.

In particular, in their colour naming Russian respondents frequently referred to *salat* 'lettuce', *morkov'* 'carrot', *svëkla* 'beetroot', *kapusta* 'cabbage', and *redis* 'radish', i.e. vegetables traditionally grown in Russia in backyards, are accessible, inexpensive and form the basis of authentic Russian cuisine (Montagné *et al*. 1961). Conversely, English respondents offered many more names derived from sweets (candy floss, toffee, sugar, biscuit, sherbet, honey). These colour terms denote colour space area between pink, orange, red and yellow, i.e. one of the hard-to-name in English (e.g. Guest and Van Laar 2000). In comparison, the unique Russian referent in this category included *zefir*, a fruit confectionery traditionally coloured white, pink or white-pink and for its airiness named after Zephyrus, the Greek god of the airy west wind (Drey 2017).

Also, referent inventories of the "herbs", "nuts", "dairy products", and "beverages" categories considerably differ between the two languages, as prompted by Table 2.

(ii) Frequency of occurrence of "edible" colour names in Russian and English

Different "edible" colour names varied markedly in elicitation frequency but certain names were offered at least twice – 90% in Russian and 88% in English. Notably, the percentage of these terms was significantly higher in Russian compared to English.

The list of the ten most frequent "edible" colour terms overlapped partly between English and Russian, specifically in: *persikovyj / peach*, *mâtnyj / mint green*, *olivkovyj / olive*, *gorčičnyj / mustard,* and *slivovyj / plum* (Figure 1). In Russian, three names with the highest ranks among non-BCTs (Paramei, Griber and Mylonas 2018) were offered most frequently – *salatovyj* 'lettuce-coloured' and two terms denoting PURPLE shades, *bordovyj* 'claret' and *malinovyj* 'raspberry'. In comparison, in English the list was championed by *maroon* and two frequent non-BCTs denoting PINK shades*, peach* and *salmon*.

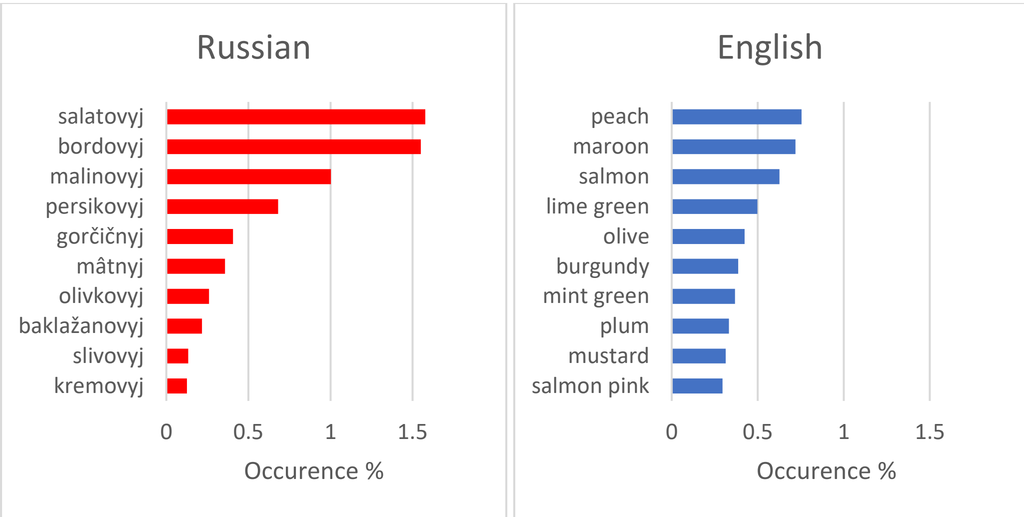

Figure 1: Occurrence (%) of ten most frequent "edible" colour names elicited in Russian and English.

(iii) Number of unique monolexemic and polylexemic descriptors derived from each object name (the term's derivational productivity)

In both languages colour terms derived from names of "edible" objects constituted a significant number: 238 terms (17%) among 1,422 Russian unique colour words and 200 terms (16%) among 1,226 English unique colour words. Approximately 28% of these were single words in Russian and 27% in English.

The most frequent colour terms, in both languages, also revealed rich derivational productivity, i.e. the number of unique mono- and polylexemic descriptors derived from the object name. In Russian, the greatest variety of descriptors was obtained for *salatovyj* 'lettuce-coloured' (21), *bordovyj* 'claret' (20), *malinovyj* 'raspberry' (14), *persikovyj* 'peach' (14), and *baklažanovyj* 'aubergine' (14). In English, the richest derivational productivity was found for *peach* (13), *salmon* (11), *lime* (10), *maroon* (10), and *olive* (9).

The colour-name derivatives were produced using the following patterns:

(1) suffixed object name; e.g. *moločnyj* 'milky' (Russian); *peachy* (English);

(2) object name; e.g. *sliva* ‘plum’ (Russian); *chartreuse* (English);
(3) compound or modified object name; e.g. *rozovyj jogurt* ‘pink yoghurt’ (Russian); *salmon pink* (English);
(4) modified suffixed object name with a colour name compound; e.g. *moločno-rozovyj* ‘milky pink’ (Russian); *peachy pink* (English).

The prevalence of these word-formation patterns is strikingly different, though, in English and Russian. In Russian, colour terms take predominantly an adjectival form of the “parent” object name with added suffixes: -ov- (*malinovyj*), -ev- (*gruševyj*), -n- (*černičnyj*), or -sk- (*burgundskij*) [i.e. (1)]. Moreover, Russian speakers use names with multiple compounds and modifiers [(3), (4)] – to convey the perceived colour with high precision (Paramei *et al*. 2018). It is also worth noting that out of 26 offered Russian colour terms that lexically are equivalent to object names [(2)], 8 apparently have emerged recently (e.g. *lajm* ‘lime’, *karri* ‘curry’, *zelënyj_čaj* ‘green tee’, *cikorij* ‘chicory’, *tykva* ‘pumpkin’ etc.), since they had been not attested in the catalogue of Vasilevich *et al*. (2002).

In English, in comparison, a colour term (adjective) is an equivalent of the “parent” object name [(2)]. To elaborate on the (2), English participants commonly offered pattern (3), i.e. object names accompanied by a BCT (e.g. *salmon pink*), lightness modifiers (e.g. *light olive, dark plum*) or emotionally laden adjectives (e.g. *dusty maroon*).

(iv) Visualizing denotata of the frequent Russian “edible” colour names

To visualize denotata of the most prominent Russian “edible” colour names, we trained a colour-naming model based on Maximum a Posteriori (MAP) program – which favours more frequent colour names over less common and inconsistent – solely by colour names related to food (cf. MacDonald and Mylonas 2010). Figure 2 presents an outcome in projection on the Munsell array, i.e. the surface of most saturated colours. It is apparent that among the 12 most frequent terms, *salatovyj* and *olivkovyj* denote the largest areas, followed by *malinovyj* and *persikovyj*.

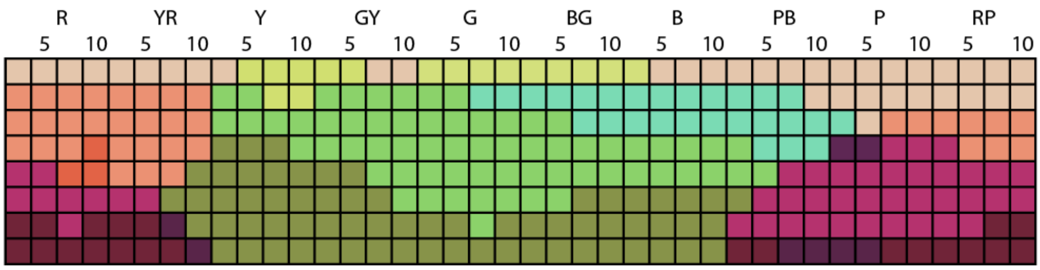

Figure 2: Denotata of 12 Russian most frequent “edible” colour names mapped onto the Munsell array (Mercator projection): *olivkovyj*, *salatovyj*, *mâtnyj*, *limonnyj*, *lajm*, *kremovyj*, *persikovyj*, *morkovnyj*, *malinovyj*, *bordovyj*, *baklažanovyj*, and *slivovyj*. An area paint mimics colour of sRGB centroid of the samples that elicited the colour name in question.

CONCLUSION

In both Russian and English, the choice of “edible” colour-term referents is indicative of availability of objects related to food and edible substances in the natural environment. The inventory of the terms also reflects the social “gastronomic” reality – established cuisine, eating habits and flavour preferences. Despite influences of globalization on the food assortment and the entire nutrition landscape, the inventory of language-specific “edible” colour terms endures as the manifestation of culture-specific culinary worldview.

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Colour Associations in Different Cultures

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ABSTRACT

The aim of this study is to investigate if there are colours that are associated with certain words. The study was conducted in nine countries (Germany, Iran, Japan, Nepal, Russia, Saudi Arabia, Sweden, Turkey and Uganda) to see if there are cultural differences in the way people associate colours with the words. The subjects were asked to match each of the words with only one colour. They could choose colours from the chart consisting of 27 colour samples selected from the NCS Atlas. In total, the dataset included 18,072 responses from 753 participants. The collected data were analysed by hue, chromaticness and the degree of blackness and whiteness. The results show that the colour associations with the words vary to different extent between the different countries. That indicates that there are universal associations with colours for some of the words, as well as cultural differences.

Keywords: *Colour associations, design, psychology, culture, architecture*

INTRODUCTION

Associations with colours have interested researchers, artists, designers and marketers for a long time. Various studies have focused on how emotions and concepts are connected with colours and colour combinations in different cultures, and if there is a coherence between different groups of people (e.g. Da Pos and Green-Armytage 2007). The aim of this study is to carry out further analysis of colour associations and to investigate if there are cultural differences in the way people associate colours with the words.

EXPERIMENTAL

The method used in this research was previously performed in 2015–2016 during a pilot study in Sweden and Nepal (Jung 2016). Interim findings revealed in different countries were reported in a series of scientific publications in 2017–2018 (see e.g.: Jung *et al*. 2017; Griber and Jung 2017; Griber, Jung and Weber 2018).

In this study, participants were given twelve pairs of words (*Warm–Cold, Sorrow–Happiness, Calm–Upset, Near–Distant, Young–Old, Feminine–Masculine, Fast–Slow, Strong–Weak, False–True, Cheap–Expensive, Friendly–Dangerous, Me–Others*), and asked to match each word with only one colour sample from a chart with 27 selected shades from the NCS Atlas.

The colours selected for the colour chart included three shades of every NCS primary colour (Y, R, B, G) and every secondary colour (Y50R, R50B, B50G, G50Y). The first shade (A) was a light shade of those eight primary and secondary colours. The second (B) was the most saturated colour, the third one (C) was a dark shade. Additionally, we included black, grey, and white into the colour chart of the experiment (Table 1).

	1	2	3	4	5	6	7	8	9
A	S 0300-N	S 0520-Y	S 0520-Y50R	S 0520-R	S 0520-R50B	S 0520-B	S 0520-B50G	S 0520-G	S 0520-G50Y
B	S 4000-N	S 0580-Y	S 0585-Y50R	S 1080-R	S 3055-R50B	S 2065-B	S 2060-B50G	S 1565-G	S 1075-G50Y
C	S 9000-N	S 6020-Y	S 6020-Y50R	S 6020-R	S 6020-R50B	S 6020-B	S 6020-B50G	S 6020-G	S 6020-G50Y

Table 1: The colours selected for the colour chart.

The study was conducted in nine countries: Germany (N=90), Iran (N=60), Japan (N=140), Nepal (N=77), Russia (70), Saudi Arabia (N=66), Sweden (N=70), Turkey (N=114) and Uganda (N=66). The countries represented in this study had different climate conditions, specific cultures and various religious traditions. In total, the dataset included 18,072 responses from 753 participants. The subjects did not have any known colour vision defects, were born and reside in the same country.

RESULTS AND DISCUSSION

For some words like *Cold* or *Feminine* the chosen colours are more or less the same in all countries and concentrated to only a few dominant colours (Figure 1). Other words like *Upset* have more variations between the countries. In Sweden almost 47 % associated *Upset* with chromatic red, in Russia – 35%, in Turkey – only 4%, and in Iran – 0%.

Figure 1. The colour diagrams of Germany, Iran, Japan, Nepal, Russia, Saudi Arabia, Sweden, Turkey and Uganda. For each word, the relative frequencies of each colour is shown in the coloumns.

Statistical analysis of the chosen colours reveals some general findings for the different words and we choose to present and discuss them word by word.

Warm: Most countries have a dominance of orange, followed by red or yellow (Figure 2). In Russia dominant are yellow and pink.

Cold: Light blue is the most chosen colour in all countries. Germany, Iran and Sweden have the strongest connection between Cold and light blue.

Sorrow: Most countries have a dominance of black, grey, brown, and dark colours. Germany sticks out with only a few subjects choosing black and grey.

Happiness: Chromatic colours. Mostly yellow. Russia: also orange. Nepal: also red.

Calm: All countries: light and chromatic colours.

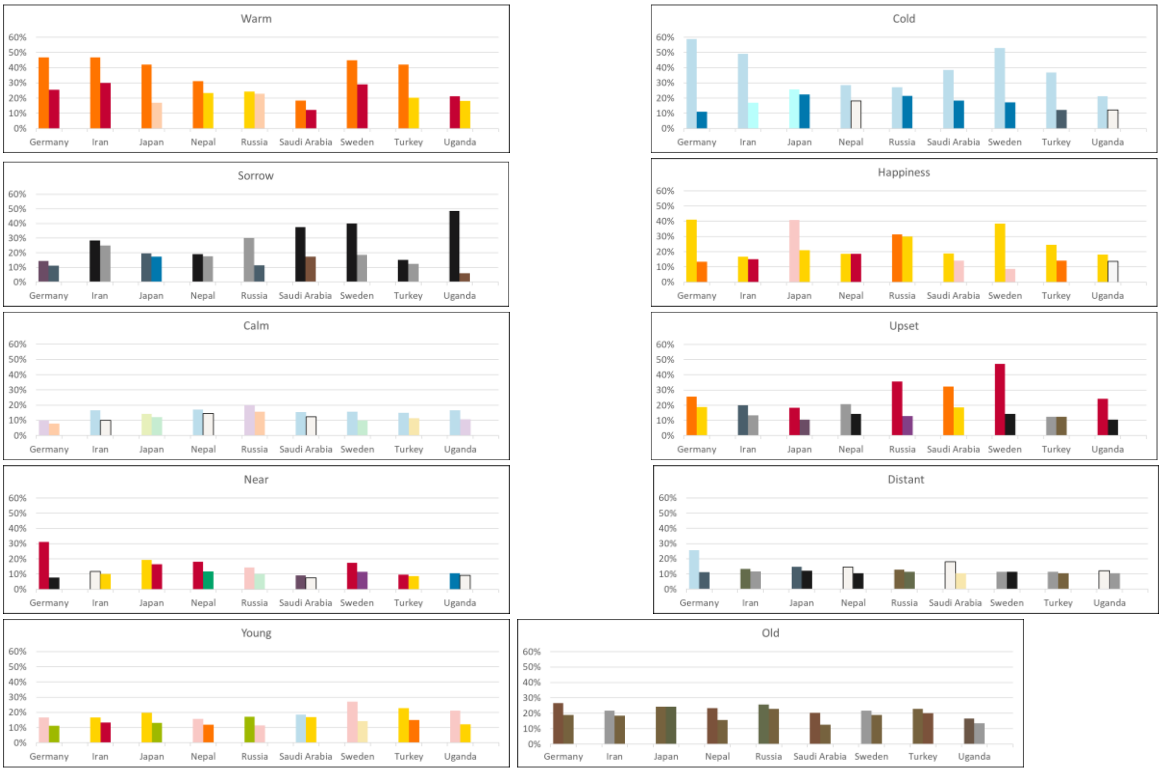

Figure 2: The two most chosen colours for the words *Warm, Cold, Sorrow, Happiness, Calm, Upset, Near, Distant, Young,* and *Old* in the different countries in our experiment. Higher bars mean a higher degree of coherence, whereas lower bars indicate a lesser degree (within a country).

Upset. Russia, Sweden and Uganda: red, warm and chromatic colours. Iran, Nepal and Turkey: dark colours and grey. Germany and Saudi Arabia: orange and yellow.

Near. In Germany, Nepal and Sweden the most chosen colour is red. In Russia this word has strong associations with pink.

Distant. All countries: many different hues and shades. Germany: light colours, whereas dominant is light blue. Japan and Russia: dark colours.

Young. In general, this word is associated with light shades. Iran, Nepal and Turkey link it to more chromatic colours.

Old. All countries: dark and brown colours.

Feminine. All countries: pink as the first choise, exept Turkey, where this word is associated with red, see Figure 3.

Masculine. All countries: dark colours, mostly black and blue or black and brown.

Fast. All countries: chromatic colours, red, orange and yellow.

Slow. More spread out hues and more light nuances than *Fast.*

Strong. All countries: black, red and chromatic colours.

Weak. All countries: light and warm colours. Nepal and Saudi Arabia: also grey.

False. Germany, Iran, Sweden and Turkey: red as a dominant colour. Nepal, Saudi Arabia and Uganda: black.

True. Nepal, Russia, Saudi Arabia and Uganda: white. Germany, Iran, Sweden and Turkey: green.

Cheap. Spread out on many hues, lighter colours than in *Expensive.*

Expensive. Darker colours and more chromatic colours than in *Cheap (Figure 3)*.

Friendly. Light and chromatic colours. Different hues.

Dangerous. All countries: red.

Me. Many different hues, many blue colours.

Others. Also spread out hues and nuances. More white and grey than in *Me.*

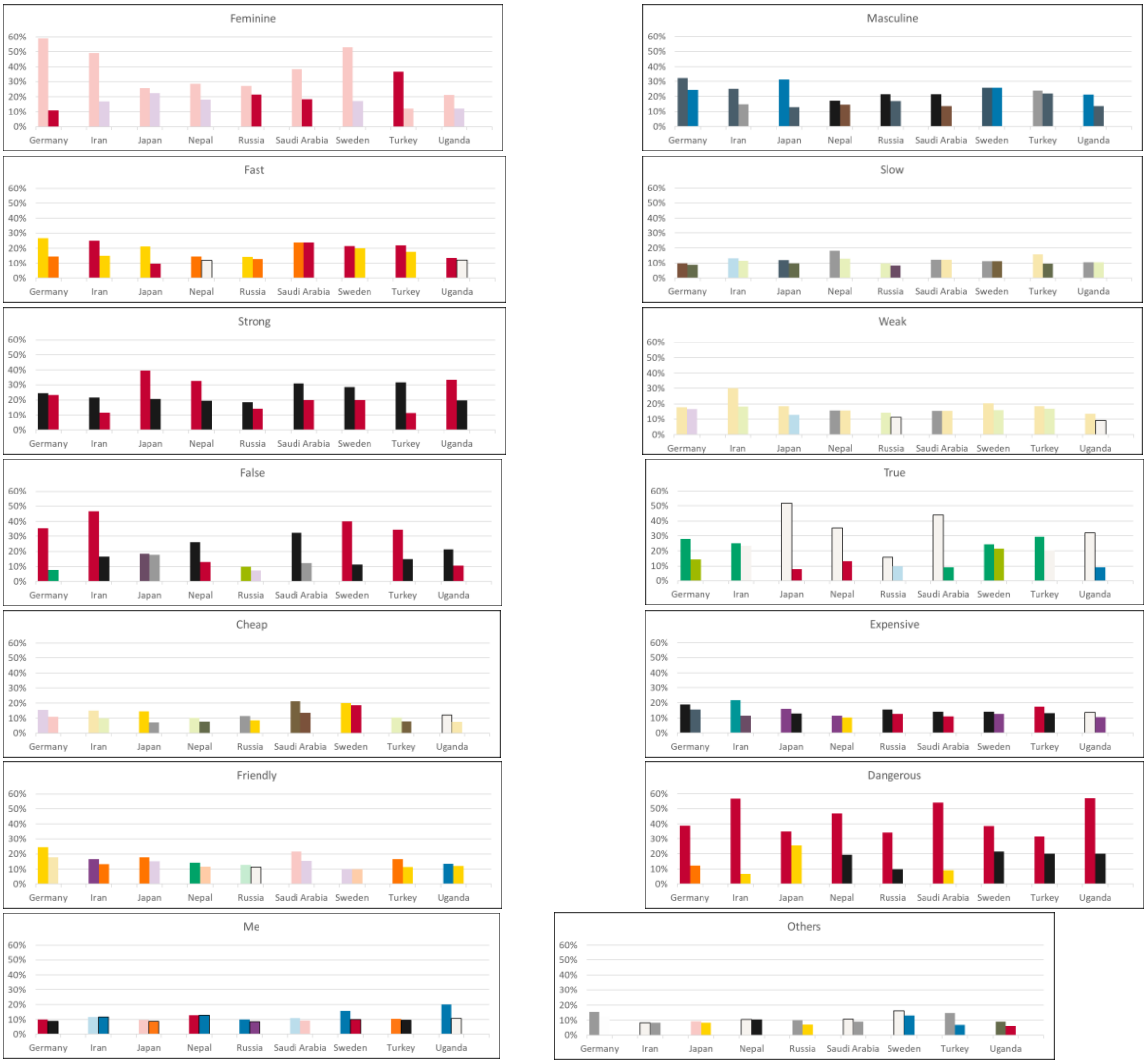

Figure 3: The two most chosen colours for the words *Feminine, Masculine, Fast, Slow, Strong, Weak, False, True Cheap, Expensive, Friendly, Dangerous, Me* and *Others*.

CONCLUSION

Our experiment affirms that there are consistent patterns in colour choices for words within different countries. The findings of this study demonstrate that the coherences between the countries are high for the words *Warm–Cold, Sorrow–Happiness, Calm, Distant, Young–Old, Feminine–Masculine, Fast, Strong–Weak, Expensive, Dangerous*. For some other words (*Upset, Near, Slow, False–True, Cheap, Friendly, Me–Others)* there are different colour associations in different countries. It would be possible, with extended studies and digital tools, to make a "colour association translator", where one can see, how certain words are associated with colour in a specific country, and this is something we plan to examine in the future. This tool could be valuable for architects, designers and marketers, who are working worldwide with colour and communication in different cultures.

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AIC LISBOA 2018
colour & human comfort

Rethinking colour as a Multisensorial experience

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ABSTRACT

In this paper I explore the interaction between colour and the human experience. The research is focused on colour as a multisensory phenomenon, where colour is understood as an active agent and more like a process. In previous research, the knowledge of colour has generally been understood through different disciplines, instead of formulating it in multidisciplinary way. In my doctoral dissertation, I have started to understand and study colour in a more holistic way. I understand colour experience to be connected not only with the human perspective but also with many different kinds of entities, such as the air we are breathing, water, wind as well as other human and non-human contacts such as technology, plants and animals. This paper discuss colour as one possible entity among other entities by using the posthuman philosophy. The research will have significant contribution to the development of teaching colours in art education.

Keywords: *Posthumanism, artistic research, relational ontology, art pedagogy*

INTRODUCTION

In my earlier artistic activity in working with colours, I have started to observe and think the multisensory experience of colours. Since my background is in the field of art education, I have started to wonder, how the phenomenon could be seen more wildly in art pedagogy in general. During my studies in Aalto University, an interesting mode of artistic research has been developing which focuses mostly on artistic thinking. In my doctoral dissertation I start with philosophical questions about multisensorial colour experience by using the artistic thinking as a frame of reference.

At the same time in the field of posthuman philosophy, same kinds of questions about multiple modes of experiencing things are raising. Posthuman research has recently started to examine the relationships between human and non-human entities. It is particularly interested in understanding the human position not being in the center of everything. This kind of discourse has been going on and strengthened during last decades when the Posthuman turn has become open.

THEORY

Posthuman theories have an increasing interest to study and play with “the others” in the field of art as well. These theories wonder, what is the meaning of the “subject” when it is connected to many kinds of relationships. What kinds of qualities are needed in the cooperation with nature and other non-human objects around us? Are they really “objects” or should we start to rethink them as active agents? This paper discusses colour as one possible entity among other entities by using posthuman philosophy as a background.

In my research I explore new ways for colour to be part of this conversation about human and non-human experience. At this point I am relying on philosopher Rosi Braidotti’s (2013) philosophy about ethical questions within the Posthuman turn. In her philosophy there are ethical questions that are related to the qualities of different kinds of entities like non-human nature or animals. According to Braidotti we should be able to commit again with other kinds of subjects by reacting and co-operating more affirmatively with them. Braidotti has pointed out also the idea of multilevel experiences.

In my research colour is discussed and considered in the field of relational ontology. I am dealing with the questions of colour to be more like a process, not a stable matter. Considering how colour can be understood and experienced as a multilevel process will expand the quality of artistic experience itself. Philosopher Alfred North Whitehead (1978) has written about the basic nature of phenomena and reality as a flowing theory. Whitehead argues in his theories that there is a misunderstanding of things in separating categories in the world instead of understanding life as a dynamic and processual way.


Figure 1: Material – non-material colour. How does the colour experience vary in our experience if it is a stable matter or not? Photo of the Senate Square lime panted wall in Helsinki, Finland.
Figure 2: Colours of the sky. Photos Nina Laaksonen 2017.

This concerns also artistic thinking, which is the main approach in my research work. In doing artistic research the focus is on rethinking the possibilities for a colours to work with “the others”. My experience with colours was born by painting and observing them in doing artwork or being in the contact with the nature. In these experiments I have been studying colours through all senses and this has eventually begin to influence my thinking as well.

EXPERIMENTAL

Later as the theoretical and philosophical issues proceeds in this research, I will look at the colour from the point of view of teaching development. In doing so, I am planning to organize a workshop in higher education, within fields of art and creative methodologies in teacher education in Finland. The teaching experiment is a pedagogical experiment of a new kind of colour thinking. From this experiment, I will research the multidisciplinary possibilities that rises from artwork and from pedagogical discussions with the students.

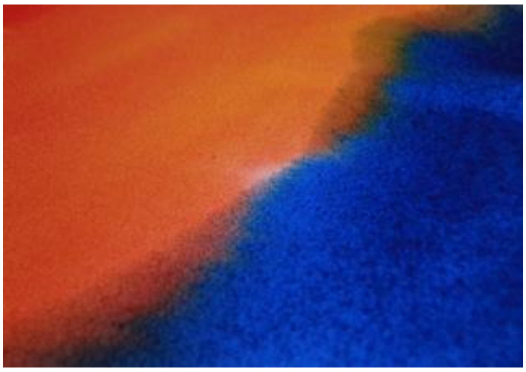

Figure 3: Colour rehearsal with blue and orange. Aalto University. Nina Laaksonen 2014.
Figure 4: Evening light with the lake. Photo Nina Laaksonen 2017.

RESULTS AND DISCUSSION

The research will have significant contribution to the development of teaching colours in art education. Art education in Finland is part of the development of new modes for multidisciplinary education in basic education. These reforms call for new suggestions that could work in collaboration with other disciplines in schools. Understanding colour as a multisensory phenomenon will expand the possibilities of teaching and learning not only art but also diverse ecological issues and values. My research will later on suggest colour to be one essential subject in that multidisciplinary work. Understanding colour as a multisensory phenomenon will expand the understanding of colour through a novel theoretical and philosophical perspective.

CONCLUSION

In this paper I have explained the underlying factors that has forced me to see something a new way. Playing with colours in the artwork has taught me to participate into our world from a different perspective and with a new approach. This has started a process that needs to be viewed and studied carefully with many philosophical frame and angle. These points of views will hopefully lead this research to expand the knowledge of colour, which is one main thing in artistic work and contemporary art or any art in general. When compiling this new information on colour and colour experience in the multilevel way, I will value artistic thinking process as a guidline to do this research.

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colour & human comfort

Our Approach to Mediation on Colours

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ABSTRACT

The association for a Museum of Colours works on different frames of exhibition to transmit knowledge about colours in their diversity, tackling their scientific but also artistic and symbolic aspects. Our team created and implemented various exhibits and studied their efficiency and impact on our audience. These exhibits and devices are classified into five categories: "Your world of colours" inviting visitors to express their own taste and understanding of colours, "Add your colours" offers visitors the possibility to (create and) use colours in different creative contexts, colours' recognition games contribute to look closer at nuances, educational games meant to teach stories and facts about colours and the "Wow"-effects, which aim at touching the sensibility of our audience to convey meaning and values. Going through this numerous experiences of creation and observation enabled us to adjust and adapt our propositions to create a permanent space for colours.

Keywords: *Mediation tools and devices, audience-targeting*

INTRODUCTION

Since January 2017, our association has been developing a cycle of four exhibitions in Flutgraben's 200 sq. m gallery space, at the heart of an artists' house in Berlin. Approximately 2500 people have visited one or more exhibitions since the first opening. Our audience is already highly diversified: beyond locals and art-aficionados, we have welcomed international audiences, families and groups of schoolers. This introduced a challenge from the beginning of the exhibitions' conceptions: how to satisfy the various desires and needs to understand of our audience? How to create exhibitions, which can be grasped and comprehended by both scholars and experts? From the narration of the exhibitions to their implementations, we created tools and devices to provide both understanding and experiences of colours. Beyond traditional formats such as texts and panels, to what extent do colours allow us to implement more interactive mediation devices? And how are our visitors impacted by these devices?

Each exhibition was divided into three areas. The Colours Lab introduced a parallel between sciences and arts to provide a better understanding of the attributes of colours. The Colours of Berlin studied the diversity of the places and roles colours occupy in our urban environment. The Colour Room focused on a specific colour and explored its multiple significations and nuances. This pattern enabled us to explore and accurately present multiple topics. Our two current exhibitions at museums in Berlin also contribute to developing our perspective and exhibits.

EXPERIMENTAL

Through these exhibitions, we implemented various types of tools and devices, which we classified into five categories.

"Your world of colours"

We first assume that each of our visitors already has opinions and pre-conceptions about colours. Thus, we invite them to express their preferences or own interpretations of colours.

For example, we exhibited a poster with 20 nuances of blue, which stated "Blue is the worldwide favourite colour, but which is your favourite blue? Put a sticker on it and discover its name". This poster allowed visitors to express their own preference while learning to better define it by using the appropriate words. Like any similar installation that we implemented, it ended up covered with stickers. We should have made it twice as big to ensure every visitor a space to put its sticker.

By directly addressing the visitors, this device enabled individuals to contribute to the exhibition by adding their personal trace to it.

"Add your colours"

We also invite our visitors to become more creative, and actively participate and engage with the exhibitions, in order to provide them with a more personal and subjective experience of colours and their uses.

During the exhibition on the colours of nature, a seedbomb workshop enabled our visitors to create their own guerilla gardening tool and to add their personal touch of green to the urban landscape. This workshop was especially successful with school classes: feedbacks from parents said that children were really happy to bring a seedbomb back home and remembered the information related to green in nature.

"Colour recognition games"

Learning about colours is also about becoming more sensitive to their nuances and to appreciate their diversity: simple games which can be played anyone three years old and up also made adults curious and enthusiastic. For instance, we developed a pairing of blue eyes game, where 49 left eyes had to find their right one: our aim was to underline the diversity that can be hidden behind the simple "blue eyes". Even if few visitors played the game until its end (it required 40 minutes, which was obviously too much), the visual of the game was enough to understand the diversity that "blue eyes" could suggest.

This led us to develop a Memory game for the *Labyrinth Kindermuseum*, introducing other colours of eyes and skins to raise children's awareness about the diversity of people. At the heart of an exhibition about diversity, our pop-up contributes to enrich children's vision of alterity and beauty.

“Educational games”

We believe learning by playing is an experience which is often overlooked in traditional exhibitions. Thus, we created a game of the goose about the history of the blue colour: through 30 cases, players got to learn about the materials used to produce blues and its meaning through ages and cultures. This was a very successful installation which was enjoyed both by adults playing in teams and by families. Players spent in average 15 minutes on the game, and got the opportunity to find out some answers, but also to learn new stories about blue.

The collaboration with the *Labyrinth Kindermuseum* brought us to develop children’s playing cubes made of six types of faces: colours of the skin, hair and eyes but also tattoos, piercings and (punkish) hairstyles contribute to individualise these portraits, for children to reconstitute them - or more likely create new ones.

“Wow”-effects

Learning can also be carried out through cognitive experiences, which leave deep traces on individuals and thus have a long-lasting meaning.

In our exhibition about the colours of nature, we built a plant tent, a space to raise awareness about the beauty of nature and the need to preserve it. This space had been inhabited in various ways, by children reading books to adults and groups of friends discussing the exhibition or enjoying a drink.

RESULTS AND DISCUSSION

The three parts of the exhibition appeared as a frame of inspiration as well as a limit: by providing glimpses of what a Museum of Colours could look like, we missed some transitions which would have allowed some more global understanding of our exhibitions’ concepts. The ways our installations got used up, the feedback that we got from visitors but also our inner team’s feedback helped us understanding what works the best and what could be improved upon: the rhythm of production was a clear limit of the possibilities we had to anticipate certain aspects (frequentation, ways to use the installations…).

CONCLUSIONS

In order to introduce the diversity of colours, our team created and implemented a wide range of exhibits contributing to the originality of our exhibitions. Establishing a permanent space to exhibit colours will obviously bring a load of new challenges, but these previous experiences will enable our team to create durable installations that give a sense of colours to our diverse audiences.

ACKNOWLEDGMENTS

We wish to warmly thank our sponsors RAL FARBEN and Caran d’Ache for supporting the production costs of these exhibitions and providing us material, the numerous exhibitions partners - artists, institutions, organisations, businesses - who lent us exhibits or facilitated their exploitation and the amazing team of volunteers who contributed to the creation of these devices and allowed these exhibitions to happen.

Effective Colour Communication

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ABSTRACT

Experimental data on describing colour samples was obtained from sixteen participants from design and chemistry/engineering backgrounds. Design participants tended to use more creative and imaginative terms, as well as a wide range of semantic fields (a term borrowed from linguistics). On the other hand, participants from chemistry/engineering backgrounds described samples objectively and more precisely. They used a limited number of semantic fields. In terms of describing the process of changing the appearance of one sample to another, participants from chemistry/engineering used technical terms and described the process more systematically in comparison to the design participant group. Participants from the design background were less likely to explain the process of changing the appearance of a sample. They tended to stay focused on the difference between samples. This research provides evidence that people from different disciplines who need to collaborate in colour design use different colour vocabularies.

Keywords: *Language, Describing colour, Semantics, Colour association*

INTRODUCTION

In the area of colour design there are two main groups of professionals that use colour and need to collaborate. These are designers and chemists. Designer colourists tend to respond emotionally to colours and materials. These colour specialists analyse colour trends, preferences, and patterns in order to predict customers' future needs and market demand [1]. Their role also involves consulting with clients, considering budgets, and developing painted colour applications for surface materials. Colour development also requires people with a chemistry background. Colour chemists tend to work in laboratories, mixing pigments and thinners in measurable quantities to create new colours [2]. They also test paint strength and durability to achieve the best functionality.

Collaboration between these two groups of colourists is inevitable throughout the colour design process from creating new colours to final product applications. This is because both functional and aesthetic aspects need to be balanced for colour design success. However, these groups of colourists often face communication difficulties. This may be because of a lack of shared and common understanding about different ways of describing colours, and because of different disciplinary backgrounds. The goal of this research is to investigate colour communication differences between two groups of participants – one from design and the other from chemistry/engineering.

METHODOLOGY

Sixteen students took part in an experiment to describe the appearance of twelve samples. These students were divided into two groups comprised of eight from a design background and eight from a chemistry/engineering background.

Six alphabetically coded pairs of colour samples were used. Each sample within a pair differed from the other as follows. Pairs A, B, and C differed in colour; pairs D, E, and F differed in gloss, texture, and colour (Figure 1). For each pair of samples, the samples were shown individually and then as a pair. Participants were asked to describe each sample and then the process of adjusting the first sample from each pair to make it look like the second in the pair. The word 'colour' was not mentioned by the experimenter during this process as it might influence participants to describe and talk about colour only.

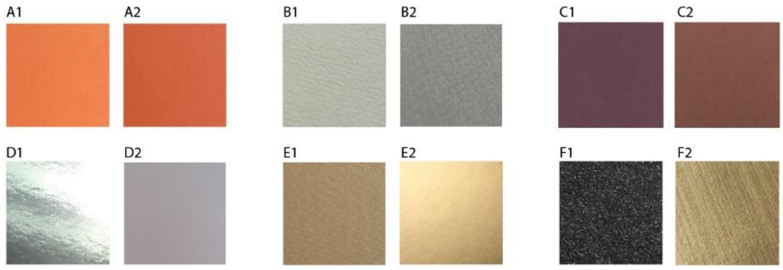

Figure 1: Pairs of samples used for the experiment.

RESULTS AND DISCUSSION

1. Evocative and emotional terms

Participants from a design background used evocative and emotional terms such as "reminds me", "it makes me think", "feel", and "it's saying to me" more often in comparison with participants from chemistry/engineering (Figure 2 and 3). Even though three participants from chemistry/engineering used emotional terms, they were still likely to describe what they were looking at objectively, focusing on the present time (Figure 4).

Disciplinary Background	Design	Chemistry/Engineering
Used Emotional/Evocative Terms	**Frequency**	**Frequency**
Feel	88	77
Reminds me	5	8
Makes me think about	46	0
It's saying to me	11	0
Total	**150**	**85**

Figure 2: Frequency of emotional and evocative terms.

Design Participant 1	***To me it's saying*** hey I'm bling-bling, I attract attention, I am shiny, I am expensive, don't touch me just look at me. (sample D1)
Design Participant 2	***I feel*** this one is more soft, hair colour, a golden hair colour, blondie, some traditional architecture. (sample E2)
Design Participant 3	***It makes me feel*** a little bit cool. (sample D1)
Design Participant 4	This colour is very warm, and ***makes me feel*** full of energy. (sample A1)
Design Participant 5	***It makes me think***. Just think my grandpa, yes ***it's like*** his clothes a little bit. (sample E1)
Design Participant 6	***It looks like*** shiny and a little bit elegant. (sample F2)
Design Participant 7	It is very confusing for me. ***It looks like*** skin colour. (sample E1)
Design Participant 8	***It makes me think about*** old things, old furniture, ***makes me think about*** 1960's (sample C1)

Figure 3: Examples of emotional/evocative language uses from design participants.

Chemistry/Engineering Participant 2	***It feels like*** a gold, golden foil, golden foil. (sample E2) It's black and ***it feels a little bit*** reflective. (sample F1)
Chemistry/Engineering Participant 4	***It looks like*** paper pulp with a beige pigment to it (sample E1)
Chemistry/Engineering Participant 5	I ***think it's just*** smooth, no rough surface. (sample C1) I ***think this looks like*** the first sample. (sample B1)
Chemistry/Engineering Participant 8	***It reminds me of*** rice paper that crinkly texture. (sample B1)

Figure 4: Examples of emotional/evocative language used from chemistry/engineering participants.

2. Associations of sample colour with images and memories

Design participants expressed their responses using adjectives about feelings and memories. These are also closely connected with evocative and emotional language uses that are mentioned above. Lawson (2004, p.93 as cited in Bartlett, 1932) says that "evocativeness of words is a function of our long-term memory which is conceptual and schemata based" [3]. The author also states that designers acquire higher levels of sophistication and elaboration in schemata for concepts they deal with [4].

Design Participant 1

Yet, still ***calming colour*** which is ***not loud***. (sample B2)
The colour is ***not too busy***. (sample B1)

Design Participant 2

You know the warm colour always reminds me of ***food like tomato, McDonald***. (sample B2)

Design Participant 3

It looks like ***wood and natural paper***. (sample E1)
It still feels a little bit ***luxury*** (sample F1)

Design Participant 4

This colour is ***out of fashion***. (sample C1)
A ***village***, some ***mountains and trees, green trees***, and it makes me feel that I am in a ***very good environment***. (sample E1)

Design Participant 5

It is more similar to ***sunset***. It is like that is ***a girl***. (sample A2)
It makes me feel like ***I am going to die***, if I see this colour everywhere
I feel as if I die. (sample D2)

Design Participant 6

This one is a little bit like ***a tissue***, it is ***being wet and being dried*** kind of.
This one is easy to be ***destroyed by water***. (sample B1)

Design Participant 7

It looks like ***Hungarian decoration***.(sample F2)
It looks like ***skin colour***. I think, so, but ***unhealthy people's face*** colour. (sample E1)

Design Participant 8

This colour makes me think about ***poor places***, ***not well organised places***, like in the very ***dirty, dirty underground*** or a ***dirty village*** (sample E1)

Figure 5: Examples of association in colour samples from design participants.

Design participants associated samples with a range of images (Figure 5). There has been a crucial place for imagination in considerations of creative behaviour and the formation of ideas [5]. For them, what they are feeling at the time may be important. For this reason, some of them did not mention the names of colours at all. Interestingly, for C2 (brown colour sample), no design participants mentioned the name of the colour while all chemistry/engineering participants did (Figure 6). Design participants were three times more likely to use terms associated with feeling/memory than the other group (Figure 7).

	Participants' responses from design background		Participant's response from chemistry/engineering background
D1	natural, earthy, blend with environment, calmness, smooth, made of card, wood paper pulp	C1	***burnt umber***
D2	chocolate, coffee, forest, feels like Africa, cosmetic foundation, hair	C2	***brown***, soil, leather, bricks
D3	wood, fence, good for clothes	C3	robust, rigid, matte, ***black finish***
D4	out of fashion, elder people like it, earth	C4	***brownish***, smooth
D5	wall, Lisbon city, buildings in Lisbon	C5	matte, ***brownish red***, earthy, pottery, smooth looking, ***browny beige***
D6	same as C1 just colour different	C6	***brown***, tan, between brown and orange, more brown side, not reflective, quite opaque
D7	buildings, house, wall	C7	wood, natural, soft, ***brown***, matte
D8	boring, autumn, sadness, old style, old building, rough, very cheap	C8	cognac, rust, ***orange***, ***slight orange***, ***mostly brown***, shoes

Figure 6: Participants' language uses in terms of sample C2.

Disciplinary Background	Design	Chemistry/Engineering
Used Associated Terms	Frequency	Frequency
Look(s) like	35	14
Think	125	35
Total	**160**	**49**

Figure 7: Frequency of terms of association.

3. Suggestion of possible application

Participants from a design background also described samples in terms of possible application (Figure 8). However, none of the participants from chemistry/engineering did so.

Design Participant 2	Packaging ***design especially the luxury brand***. (sample E2)
Design Participant 3	Maybe this is ***good for clothes***. (sample C2)
Design Participant 6	It makes me feel like the ***package for the wine*** kind of. (sample F2)
Design Participant 7	When I ***design for … sophisticated design***, I will ***use that kind of grey colour***. (sample B1 & B2)

Figure 8: Example sentences of possible applications

4. Expression of personal preferences

Five out of eight design participants expressed their personal preference whereas only one person from chemistry/engineering showed a preference (Figure 9).

Disciplinary Background	Design	Chemistry/Engineering
Used Terms	Frequency	Frequency
I like	10	1
I do not like	10	0
Total	**20**	**1**

Figure 9: Frequency of preference terms.

5. Describing how to change one sample to the other

In terms of describing how to change the first sample in a pair to look like the second, design participants often ignored this. Some of them focussed on differences between samples and their own feelings instead of a practical method of making samples the same. In contrast, all of the chemistry/engineering participants explained how to make the sample in each pair match. The terms used by them to answer this question contrasted with the responses of design participants. They used technical terms and explained the process systematically (Figure 10).

	Participants' responses from design background
D1	OK. I can try it to ***add a colour*** to it. (sample A1 & A2). ***I wouldn't change***. (sample F1 & F2).
D2	E2 gives me a bit more ***feeling of richness and luxury***, the other could be replaced. (sample E1 & E2)
D4	Actually, I will ***add grey*** to the B1. (sample B1 & B2)
D5	***Add sticker*** to change the textile. (sample E1 & E2)
D7	There is ***no change*** for me. (sample F1 & F2)

	Participant's response from chemistry/engineering background
C4	***Electro-coat*** with some gold. (sample F1 & F2)
C7	There is a ***very scientific way of*** it. Because I can see this one is probably ***copper***, so this one probably another kind of ***iron*** base metallic. You put in different sign of the ***power like plus(+) sign*** and ***minus(-) sign***. (sample F1 & F2)
C8	I know that would ***absorb some of the reds wavelengths***. (sample A1 & A2)

Figure 10: Sentence examples of participant strategies for transforming samples.

6. Trying to touch (behavioural characteristic)

Various scholars claim that moving the body in natural ways and touching things help the way they engage emotionally with tasks and affects how what is being evaluated is perceived [6-8]. It was observed that three out of eight design participants tried to touch or asked to touch samples although they were asked not to. However, they described samples as if they had touched them. In contrast, none of the participants from chemistry/engineering ask to touch samples.

CONCLUSIONS

Traditionally, scientists tend to value objectivity and methodological precision, whereas designers and artists tend to value creativity and might express their ideas more subjectively. Language used by design and chemistry/engineering students probably reflects the emphasis and values within their different disciplines.

The concept of the semantic field borrowed from linguistics is helpful here. Semantic fields is defined as "one way of imposing some order on vocabulary is to organise it into 'fields' of meaning. Within each field, the lexemes interrelate, and define each other in specific way" [9]. A wide range of semantic fields of natural features, feelings, emotions, colours, and temperature were used by design participants. They used sematic fields creatively and imaginatively in their description. On the other hand, participants from a chemistry/engineering background used a more limited range of semantic fields focusing heavily on colour. They used more precise language and terms in their description.

The examples of language use collected in this study provides evidence that people from a design background use a more abundant vocabulary than people from a scientific background. These comparisons are not intended to suggest negative or positive judgements by the researchers but to describe the different values of these participants. The results of this research offer additional ways of understanding different approaches in describing colours. The research provides justification for further study of communication between colour-using professionals in the work place.

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The Symbolic Meaning of Colour Terms Related to Architecture in Chinese Poetry

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ABSTRACT

The symbolic meaning of colour terms related to architecture is embedded in traditional Chinese poetry. The symbolism serves as an inherited aspect of Chinese cultural identity, deeply rooted in each generation's memory. The aim of this paper is to explore the value of architectural colour to colour terms, and the core attribute of those colour terms. Twelve kinds of colour terms, which include names for colour, names of categories of architecture, and architectural components across five Chinese Dynasties have been studied. As the symbolic meaning of colour terms are decoded, the paper finds that the architectural colour, as a variable, significantly affects the expression of the meanings, and those meanings and symbols are inclined to be consistent historically.

Keywords: *architectural colour, symbolic meaning, Chinese poetry, inheritability*

INTRODUCTION

Colour plays an important role in our communication, for example 'colourful language' and 'colour symbolism' convey various information (Tacon, 1999, p. 121). Thus, the study of colour terms can help us to uncover a great deal of underlying information. The nomenclature, meaning and value of colours may all be derived from their constituent materials (Gage, 1999). Therefore, the study of those colour terms promotes our understanding of the real built environment. The data of this research has been collected from three online corpora, the Souyun Poetry Retrieval, the Encyclopedia of Poetry and the Complete Collection of Poetry (*诗词查询*, no date; *诗词大全* no date; *唐诗宋词元曲和近现代诗词大全*, no date). In those corpora, only the colour terms of poetry that are written from the Tang Dynasty to the Qing Dynasty are chosen (ca. 618 -1912). In Chinese poetry, each colour term related to architecture is a combination of two characters: the first character is the name of the colour, the second character is the name of the category of architecture (typology) or architectural component (component).

Images are deemed as prerequisites of symbols, although, colour terms are not actual images, they can still be regard as symbols. The following observation has been made:

> *'In order to avoid confusion, we must note that the symbol need not always be offered to the outer senses; it can also be shown to the inner eye, to the imagination [Vorstellung], through speech'.* (Vischer and Yanacek, 2015, p. 421)

In Chinese poetry, the colours are ideal ones. Hence, each name of the colours only represents a group of analogous colours within the same hue. In this research, ten names of colours are tested in the three corpora, of these, five colours are chosen. In modern Chinese, the meaning of the character 红 is pure red, but historically its definition is pure red mingled with white (*说文解字*, no date). The word 朱红 means vermilion which is constituted by two characters 朱 and 红, then 朱 is used as the abbreviation of vermilion, occasionally, the 红 is also used as the abbreviation of vermilion, especially when the poets are balancing the tonal patters. Moreover, vermilion is also the main ingredient of the traditional red architectural paint. Thus, in Chinese poetry both 朱 and 红 all mean vermilion. The literal definition of 紫 is the mixture of blue-green and red (*说文解字*, no date). In the field of architecture, its name is either derived from the colour of the glazed tiles; or from the vermilion perceived in a dim light; or perhaps from the Polestar [紫薇星] which represents the Emperor. In this paper, it will be named grey-lavender. The definition of the character 青 is either the colour of the East or the colour bluer than blue (*说文解字*, no date). While in the field of architecture, it is derived from the colour of the glazed tiles, earthen tiles and earthen bricks, therefore, this research employs the name earthen-grey. White is derived from the colour of plaster. Subsequently, the five colours are reduced to four colours. As for the typologies and components in the three corpora, only seven of them are frequently employed as the components of the colour terms: storied building [楼], pavilion [阁], palace [殿], house [屋], door [门], window [窗], eaves [檐] and wall [墙].

RESULTS AND DISCUSSION

All the symbols - the colour terms - are classified into four groups according to the four colours (see Table 1). In each group the signifier and signified are arrayed in parallel, the signifier is the literal meaning of symbols; the signified is the actual meaning of symbols. Based on the detailed explanations of the signifier and signified, it can be seen that each signifier corresponds with the signified, i.e., each colour term has several symbolic meanings.

Here colours are not employed for a descriptive purpose, but are used as one of the components of the fixed unity, symbol, and play a determinate role in the production of the symbolic meaning. For example, regardless of being composed by any typologies or components, all the symbols related to grey-lavender contain the actual meaning of royal architecture; while, those related to white do not contain such kind of meaning.

Every symbol contains the actual meaning of a Taoist building and a Buddhist building more or less, which implies these two religions are inclusive toward the architecture and colours, but it does not mean colours lose their influence when they are combined with religious architecture. On the contrary, it proves the significant determinate role of those colours, since they can differentiate the peculiar property of religious buildings from the general impression, for example, temples associated with vermilion are royal or exalted, while temples associated with white are secluded or normal.

The signifier	The signified
Vermilion storied building	Royal boudoir, Noble mansion, Gentlewoman's boudoir, Night club, Buddhist temple, Divine house, Taoist temple
Vermilion pavilion	Royal pavilion, Noble mansion, Beauty's residence, Night club, Buddhist temple, Taoist temple
Vermilion window	Royal boudoir, Gentlewoman's boudoir, Night club, Buddhist temple
Vermilion wall	Royal palace, Noble mansion, Night club, Gentlewoman's boudoir, Buddhist temple
Vermilion door	Royal palace, Examination hall, Noble mansion, Beauty's residence, Night club, Buddhist temple, Taoist temple
Vermilion eave	Noble mansion, Night club
Grey-lavender pavilion	Pavilion of the royal palace, Buddhist temple, Taoist temple
Grey-lavender hall	Royal Court, Buddhist temple
Earthen-grey storied building	Refined mansion, Gentlewoman's boudoir, Night club, Tavern, Buddhist temple, Taoist temple
Earthen-grey pavilion	Royal Court, Royal pavilion, Noble pavilion, Buddhist temple
White storied building	Poets' pavilion, Buddhist temple, Taoist temple
White house	Recluse cottage, Civilian residence, Buddhist temple

Table 1: The signifier and signified of symbols, colour terms.

There is an antithetical relationship between symbols related to white, and those related to the other three colours: the signified for white symbols always refers to plain architecture; while, the signified of others usually refers to rich architecture. This antithetical relationship further verifies that the four colours have a determinate role.

The ratio between the usages of colour terms of the four groups in every dynasty is very similar to each other, especially those related to vermilion and earthen-grey (see Figure 1). This phenomenon suggests poets and even audiences in different dynasties keep a unanimous view of architectural colour, colour terms and their meanings. Among all of the colour terms, those composed by vermilion and earthen-grey are always in a great measure compared with others in each dynasty, which means their symbolic meanings are disseminated extensively as common notions in the five historical periods. Accordingly, the above two examples attest to the fact that those two kinds of colour terms have a clear inclination of inheritability.

In both the Yuan Dynasty and the Qing Dynasty, the use of the colour terms of all the four groups is found substantially less frequently, compared with the other three dynasties (see Figure 1). This could be caused for two reasons, on one hand, in the Tang Dynasty and the Song Dynasty more poetry was composed, since they were the developing and maturing stages of Chinese poetry, while less poetry was written in other dynasties; on the other hand, both the Yuan Dynasty and the Qing Dynasty are ruled by the nomadic nationalities, the Manchu and Mongolian and they are different from other regimes in that they are dominated by the Han nationality. Therefore, it can be seen that politics and culture exert extreme impacts on the usages of colour terms related to architecture.

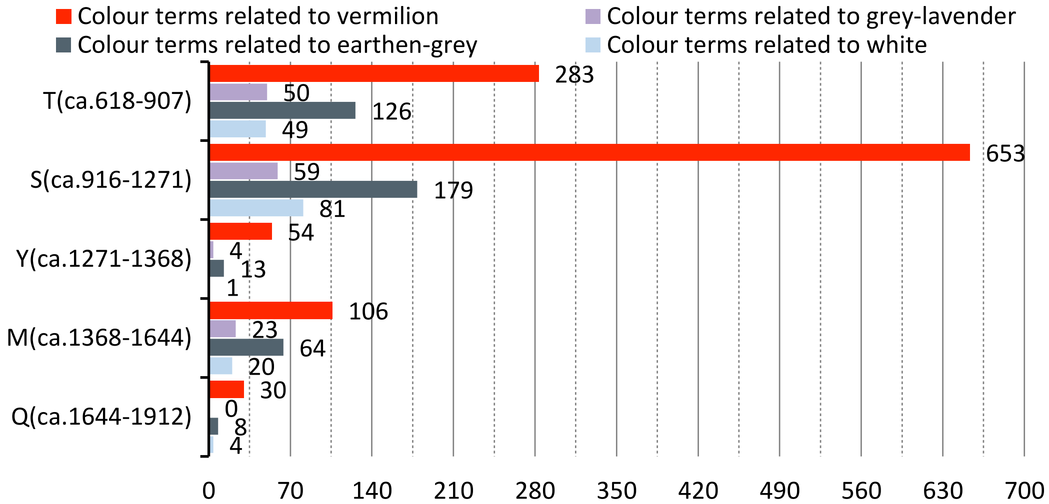

Figure 1: The ratio between the usages of the colour terms of the four groups within each dynasty and the different frequencies of the usages of the colour terms which are composed by the same colour between the five dynasties. (Note. T: Tang Dynasty, S: Song Dynasty, Y: Yuan Dynasty, M: Ming Dynasty, Q: Qing Dynasty).

Colour terms with the same hue are not always composed by the same kinds of typologies and components historically. Over the five dynasties, each trajectory of the combinational relation between the same colour and different typologies or components is uneven, and does not follow the same tendency (see Figure 2). The trajectory related to earthen-grey has two nadirs located in both the Yuan Dynasty and the Qing Dynasty; while, each of the other three trajectories has one nadir that is located either in the Yuan Dynasty or the Qing Dynasty. As mentioned before, those two dynasties are special epochs, that proves even the composition of colour terms related to architecture is also under the influence of politics and culture.

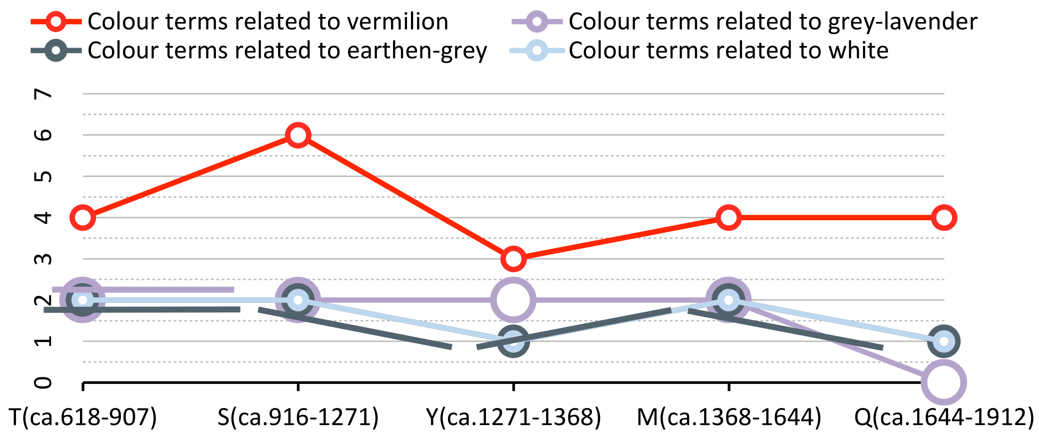

Figure 2: The colour terms with the same colour are composed by different kinds of typologies and components in each dynasty. (Note. T: Tang Dynasty, S: Song Dynasty, Y: Yuan Dynasty, M: Ming Dynasty, Q: Qing Dynasty).

CONCLUSIONS

Generally speaking, in this research, all of the information converges on two aspects, namely the determinate role of the four colours and the inheritability of the symbols. As for the determinate role, colours are not the dispensable appurtenances of architecture. On the contrary, they decisively affect how people perceive, sense and comprehend the built environment. Concerning the inheritability, the signifier and the signified of the symbols related to vermilion and earthen-grey are sustainable over the five dynasties, meanwhile, the other two colours also share the analogous inclination. The understanding of this special property may help us to use architectural colour in a more informed way. However, to find a precise rule to follow is unrealistic and unnecessary, since it is driven by various contingencies, such as the politics and culture. Further research into the authentic incentives and driving forces is far more crucial.

Although this research cannot elicit that poetry has any direct influences on the application of architectural colour in practice, it could inspire architects to use colour in the build environment purposively and predictively. Architects may learn from the past, and consider the historical experiences as well as the future consequences, in order to use colour as an 'overall philosophy of clarity and unpretentiousness' (McLachlan, 2012, p. 135). This paper is the result of studies of the symbolic meaning of colour terms in relation to architecture from the perspective of traditional Chinese poetry. More pervasive study and proof needs to be further explored in the relative areas, such as classic Chinese philosophy, laws, politics, and religions and other aspects of Chinese culture.

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Colour on the Hydraulic Tiles on the Colombian Caribbean Case of Study, Barranquilla

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ABSTRACT

This investigation project is focused on the recognition and acknowledgment of the cultural and historical aspects, as well as aesthetic and chromatic values, which represent the distinctive designs of tropical architecture, its trajectory and validity along time. Framing hydraulic tiles from buildings with republican and modernist architectural typologies as products of the Colombian Caribbean's patrimony.

As an initial study case, an analytic study of the graphic patterns and the chromatic palette of the tiles have been conducted in Barranquilla, Colombia. Which is considered the national epicentre of the arrival of a variety of cultural currents, who brought with them, new materials and construction technology amidst the industrial booming of south american countries.

The resulting hydraulic tiles represents the graphic heritage of the Caribbean, due to the diversity of patterns and colour palettes adapted to the regional context and stylized into formal and chromatic elements that render characteristic of its architecture.

Keywords: *Hydraulic tile, Colour, Barranquilla, Historicism, Caribbean*

INTRODUCTION

Between the XIX and XX centuries, the hydraulic tiles had an important heyday on south european countries. In first place, due to the invention in 1824 of Portland cement by Joseph Aspdin in England, principal raw material needed in its fabrication, as well as, the relative facility and economy on its elaboration which combine craftsmanship and technique. Spain became one of the main exponents in the use of the hydraulic tiles, hence influenced Latin America's young republics because of its commercial and cultural bonds. Between them we find Colombia, because of the colonizer past of the country, and especially its Caribbean region, that due to the harbours located in its cities on the coastline, which became arriving points for foreigners, their customs and a big diversity of products, among those the hydraulic tile. In the beginning of the XX century, the Colombian industry was too premature which led to the import of many products and materials from abroad, it was then when the hydraulic tile makes its appearance as an ornamental element, which would make a mark in the aesthetics of a big number of buildings of the time.

The goal of the document is to recognize and analyze the colour and graphic richness of the hydraulic tile on the Colombian Caribbean, taking as a study case the city of Barranquilla, with the aim to create a methodological archetype, that could be used in the other important cities of the Colombian Caribbean such as Cartagena and Santa Marta. First of all, this investigation have been narrowed down, to the period of history on which the city had the biggest boom on the use of the hydraulic tile. On second place, 30 buildings have been chosen whose formal characteristics, aesthetics and implementation of the hydraulic tiles stand out, on them a field work have been conducted which consisted on both a photographic and graphical study of their tiles. After classifying and listing the information gathered on the hydraulic tiles studied, the colour schemes have been analyzed through software, thus having enough tools to formulate conclusions about the cultural-economic-aesthetic-chromatic universe that surrounded the use of the hydraulic tiles in the Colombian Caribbean.

THEORY

Barranquilla, in its evolution and different from other representative cities of Colombia, has a particular place because unlike the other important cities in the country, such as Bogota, Cali or Medellin, it wasn't founded during the Spanish colony; it's growth and development was thanks to its strategic position between Santa Marta and Cartagena and its connection to the Magdalena River and the Caribbean Sea, consequently turning it to a transit point for trading products into the country.

The city does not celebrate its foundation, on the contrary, it was declared Villa on the 7th of April 1813, and it was not until the XIX century, that the city has its economic and political uprising thanks to the construction of its harbour on 1893; many waves of immigration led to economical and ethnological wealthness with the arrival of foreigners, whom for different reasons came to the city and ended up staying in it. Among the different nationalities, Spanish, Italian, Lebanese, Palestinian, German, an others can be found whom gradually with the native producing one of the most cosmopolitan and pluricultural cities of Colombia.

On the Republican era (1848 - 1940), Colombia and especially Barranquilla went through significant events and change processes that got materialized on a distinctive architecture, making a radical change on the aesthetics provoked by the rejection of the colonial influence, the desire for progress, and modernity. Which resulted on new styles that led to an eclectic architecture with strong influences from the countries of origin of the immigrants established in the city, such as: French Neoclassicism, Baroque, Neogothic, Art Nouveau, Art Deco, Mudéjar among others. These were contextualized to the shapes and colours given by the nature, culture and weather of the Colombian Caribbean. This eclectic development of architecture found its zenith on El Prado, an urban project in Barranquilla based on Ebenezer Howard's theory of "The Garden City".

EXPERIMENTAL

The investigation for the study case of Barranquilla was divided into four stages:

1. Space and Time Context

By means of a fieldwork, supported by historical records, it was determined the period of time and in which sectors of the city of Barranquilla were the most appropriate for the purpose and scope of this investigation, as well as other facts such as the conservation state of the floor, and the variety and extension in the use of hydraulic tile. Based on these criteria it was chosen to focus the investigation during the period in which the French Neoclassical movement, usually known as Republican, and the modernist movements (as well as the transition period between them), were the main aesthetic stiles in the city. Because, it is during this time that the biggest variety of graphic and chromatic information can be found in the hydraulic tiles. From the geographical point of view, the investigation was centered into two areas of the city: Centro Historico and El Prado, it is in these areas were a large number of architectural buildings with a high formal and aesthetic value from those periods of time can be found. Also, most of these buildings are kept in a good state and thus allowing the appreciation of both the variety and quantity of the characteristics of the tiles.

2. Gathering of information and images

Due to the architectural richness of Barranquilla, 30 buildings were chosen to conduct the research, divided into two areas, that number being considered enough to visualize the whole chromatic and graphic development of the hydraulic tile in the city. It is relevant to state that the buildings selected were completely heterogeneous, in order to determine if their characteristics vary depending on the type of building or its architectural planning. Also a research was held about the industrial genesis that surrounded the production of the hydraulic tile in the city and its process of production, as a trade that combines both technique and craftsmanship. The work of gathering and documenting all the information, especially the one regarding the graphic design of the tiles found in the buildings, was done with an interdisciplinary team of architects, graphic designers, and photographers.

Building	Architectural typology	Area	Original Use	Current Use
Parroquia N.ª S.ª del Carmen	Republican	El Prado	Religious temple	Religious temple
Centro Cultural Comfamiliar	Republican	El Prado	Housing	Cultural
Biblioteca Meria del Mar	Art Decó	Centro Histórico	Cultural	Cultural
Hotel Victoria	Republican	Centro Histórico	Service	Commerce

Table 1: Excerpt of the buildings chosen for sampling the hydraulic tiles in Barranquilla.

3. Chromatic and graphic classification of hydraulic tiles in the city of Barranquilla

The analysis and classification of the tiles is supported on existing literature about ornamentation and especially hydraulic tiles, those titles being Barcelona Tile Designs (Hernández, M.2006), Havana Tile Designs (Hernández, M.2007) and Handbook of Ornament (Meyer, M.1987), among others.

Figure 1: Excerpt of the tile design photos used for the project.

The aforementioned material, have been used as references and it have been combined with software tools such as AutoCAD and Adobe Illustrator along with other tools such as Albert Munsell's colour organization system, in order to establish graphic patterns along with the analysis of the colour schemes. Samples had been taken in the chosen buildings and classified according to the methodology proposed on The Munsell Book of Colour Nearly Neutrals Collection, widely used on architectural preservation study cases.

Table 2: Excerpt of the tiles chosen for sampling.

Building	Architectural typology	Area	Graphic pattern	Colour scheme
Parroquia N.ª S.ª del Carmen	Republican	El Prado	Phytomorphic, geometric and plain	#29241f RGB:234/221/233 #b9a790 RGB:234/221/233 #eaddcb RGB:234/221/233
Centro Cultural Comfamiliar	Republican	El Prado	Phytomorphic and plain	#2c2d2f RGB:44/45/47 #f3f3f3 RGB:243/243/243 #515151 RGB:81/81/81
Biblioteca Meira del Mar	Art Decó	Centro Histórico	Geometric	#85b4aa RGB:133/180/170 #4a353a RGB:74/53/58 #d8c7a4 RGB:216/199/194
Hotel Victoria	Republican	Centro Histórico	Phytomorphic and geometric	#c680061 RGB:198/128/97 #8ea999 RGB:142/169/153 #633236 RGB:99/50/54

As a result, an inventory was obtained in chronological order of the hydraulic tiles found in the buildings. An excerpt of the photos of the tiles design taken on the sample buildings can be seen in Figure 1. In table 2, an excerpt of the detailed classification made can be found, which includes, the graphic pattern and the chromatic palettes found on of each of the floors of the sampled buildings.

RESULTS AND DISCUSSIONS

After analyzing the different types of hydraulic tiles in the city of Barranquilla, three types of graphic patterns were found as the main ones: phytomorphic, geometric plain -with no graphic pattern-, and colour schemes ranging from the simplest with one colour on to more complex ones with up to seven colours. For the buildings, with Republican typologies the most used graphic pattern found, was the phytomorphic with 48,3%.

Also, a correlation has been found between the relevance of the building or the social class of its owner and the level of complexity in the graphic design pattern and colours used in the hydraulic tiles, which becames more complex as it climbs the social ladder; because of this, inside the same building it’s usual to find hydraulic tiles with different patterns, especially those in the higher economic class.

During the period of transition to modernism, a mutation process in the graphic design patterns of the tiles can be found, as it moves from phytomorphic patterns to more diluted and geometrical ones.

CONCLUSION

The driving force for the immense variety, both in colour and graphic design, of the hydraulic tile in Barranquilla during the Republican era, stretched to modernist movement, was fed by society's desire for progress. This society used the hydraulic tile as an element that could express their sociocultural level, cultural heritage and purchasing power, they resort to it as an individualizing and representative element of their personality.

It was thanks to the fast transition from importing to national production that a whole new universe was open for the hydraulic tile with a new dimension of more vibrant and joyful colours, characteristic of the Colombian Caribbean. This characteristic allowed the hydraulic tiles to provide a hierarchy inside the spaces of the building, determined by a big variety of resources and formal and colour values that were given to enrich the perceptive experience of the user inside the building.

During the transition to the modernist movement and with the arrival of flamboyant new styles such as art deco, a simplification and geometrisation of the patterns gave way to the creation of puzzle-like compositions of infinite possibilities, enhanced with the colours of the Caribbean. According to semiology, the information found on the hydraulic tiles of the studied areas is able to tell and make a description of society's cultural processes during the Republican era of the city.

Most of these hydraulic tiles loaded with a great variety of resources and formal, chromatic and graphic values, show influences from artistic currents such as Art Nouveau and Art Deco, at the same time, they are also influenced by the Romanesque-Byzantine, the Renaissance, Greek and Islamic art, finding possibilities of mixtures between the fitomorphic and geometric, resulting in an eclectic style

The chromatic values stand out because of the use of more vibrant and contrasting colour schemes, possibly extracted from the natural surroundings of the region. Also, these add to the intention of the tiles as a social identifier and an important part of the designed ambiance.

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Qing: the first of five colours.

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ABSTRACT
In ancient China, Qing could describe a whole array of hues that nowadays seem to us absolutely far from each other: azure, blue, green, glaucous, greenish hues, dark blue, steel blue, marine blue, bluish hues, black and grey. This research aims to investigate the symbolic meanings and cultural bearing to which this chromatically ambiguous term referred to, trying to unearth - in art, within social customs, in mythology, in philosophy, in alchemy and traditional Chinese medicine - the reference hue and, in case there should be any, the symbolic meanings still in use in the In-between Land to date.

Keywords: *Green, Blue, Ambiguity, Tradition, Symbology.*

INTRODUCTION

If I am asked where I do abide,
I traverse the clouds and hide in green
(Xu Xuanping)

In ancient China, Qing, the first of the five colours in the chromatic scale, presents a tonal indefiniteness common to many cultures even ones distant from each other.

In the present day it is no longer employed as a term to distinguish and identify a basic colour, but it is used to convey concepts, to form composite words and to communicate the meaning of 'youthful' in a figurative way.

In ancient times it could indicate a range of hues that nowadays look completely diverse: azure, blue, green, glaucous, greenish hues, dark blue, steel blue, marine blue, bluish hues, black and grey. It was essentially the colour of a type of jade with shades ranging from pale green-azure-grey up to black which was associated with spring, wood, East and the sour taste; it described the colour of nature and the sea, of mountains seen from a distance, in such a way that to reach its exact definition scholars of ancient languages suggest to circumscribe the term to its historic context and the circumstances in which it is used.

GREEN OR BLUE?

Apparently the original character indicated new green shoots with their meaning of life, youthfulness and growth, as a matter of fact its ideogram carries within it the concept of unripe, of incomplete: an observation that argues the case in favour of its use especially as indicator of the colour green; nevertheless Q*ing* was also often used to describe the hues of the sky, it ranged up to dark tones close to black and to black itself, as it is found in the texts of some poets who used it to describe the colour of eyes or hair, in my view, with the symbolic intent of 'clear' and 'youthful'.

It would appear nonetheless that dark blue of deep sea and night sky had its own specific place in *Suwen*, the ancient treatise of Chinese traditional medicine that mythology dates around 2697 BCE during the reign of the yellow emperor. Here the subdivision of the series derived from the theory of the five elements are also organised in base six with the addition of another term; we thus find that "The six colours are green, red, yellow, white, black, plus dark (*xuan*) the colour of deep water or night sky which evokes the unfathomable original mystery" blue were also the tiles that covered 'the Sky Temple' (1420 CE) also called 'Altar of the Sky', where emperors went for the winter solstice to sacrifice animals, silks and jade to the gods.

The term *xuan* is still used today to define darkness and even black and their relative meanings such as: profound, obscure, intricate, mysterious.

Indeterminateness between green, blue, and black has also been passed down through observations of the sky and nature made by the 'School of empty void'; a forgotten school of thought of which we find some memory in the *Han* dynasty (206 BCE – 220 CE), as the well known Italian orientalist Carlo Puini recounts in his book: 'Old China': "According to this school of thought the sky is an optical flaw. If for example we look at mountains from a distance, they look blue and if we look down in the depth of the valleys, they look black. In the same way blue (of daytime sky) is not a colour of reality; neither is black (of the night sky) physical. The infirmity of the human eye prevents the truth to be known, this is why man calls the sky 'the immense blue." An observation we find in Leonardo da Vinci's thoughts on aerial perspective.

GREEN AND BLUE IN ART

Through finds of ancient vessel-tablets of circular, triangular and cubical form Chinese archaeology shows that the green pigment was already in use in the late Shang period (1300-771 BCE). These vessels fashioned out of bronze or ceramic, marble or jade housed five depressions for the five basic colours: white, black, red, yellow and green and a central depression for the dish to blend the pigments; in none of these depressions were traces of blue ever found which, nonetheless, was apparently already employed in the form of ground lapis lazuli or azurite, while the special greenish-blue hue (Qing) present appears to be obtained mainly from malachite. In spite of this a certain confusion may arise owing to the fact that often malachite and azurite, both basic copper carbonates, are found mixed together creating a hybrid known as "azurite-malachite" or "azuritemalachite": the same chromatic blend found in the term Qing, so much so that the two minerals appear both in ancient and modern texts with different names but whose root is always Qing.

Green and Blue have decorated ornaments for centuries reaching peaks of incomparable beauty during the Song dynasty in the monochrome expression of lavender blue enamels, realised with pigments derived from cobalt imported from Asia Minor.

Best known among all is 'Han Blue' also known as 'China Blue: a pigment of synthetic origin derived from a barium-copper silicate obtained about 2000 years ago bringing materials to extremely high temperatures.

SYMBOLISM OF GREEN

In the various chromatic representations that in Chinese mythology speak of the dwellings of the Immortals there is also the 'Green Jade Palace’ which brings together the veneration for this rare material of esoteric virtues, the qualities of colour, probably an extremely precious emerald green which reveals, besides victory over death, the prerogative to donate longevity and prosperity to the chosen mortals.

In China also symbolism of the colour green derived, as with every ancient civilisation, from its connection with the enduring renewal of the plant world after the winterly death.

Green is thus associated both with growth, the reawakening of nature and with the sun rising in the East and because of this symbolic and augural meaning it was the colour of roof tiles on the palace, home of the emperor’s children, heralding the presence of the young princes: the new shoots of royal stock that were starting to grow. Green was then the colour of East and it was to the Green Emperor, considered the god of renewal, that one of the five sacred mountains was dedicated: T'ai Chan, on whose peaks the rites ‘of the Sky and of the Earth’ were officiated since the first emperor of the Qin dynasty (221 BCE).

The mountain, with its wealth of vegetation and medicinal plants, was reputed to be the dwelling of divinities, the sacred incarnation of ‘the goddess of emerald clouds’.

Green, with its promise of life, returns in the funeral apparel as finds from the Mancheng tombs testify where the bodies of Liu Sheng, brother of the emperor Wudi (156-87 BCE) and of his wife Dou Wan were found wrapped in shrouds made of grey- green jade tesserae stitched on red cloth with gold thread.

GREEN AND BLUE: INDICATORS OF RANK

With regard to clothing, green and blue were an indication of social status. Green was linked to lower rank officers, while blue distinguished the scholars, whose uniforms were dyed with indigo, which ancient sources point out as being already known at the time of the legendary Xia dynasty (2100-1600 BCE); blue was certainly a distinguishing element for officials during the Ming dynasty (1368-1644 CE) who were able to hold office only after passing the extremely hard government exams. The colour blue in such a way signified the position gained and recognition for the excellent results at the same time.

With the Cultural Revolution, blue and green lost their historic characteristic of distinguishing mark of social and cultural status, and were conformed to the colour of Mao’s uniform, taking on the meaning of colour of the revolutionary people.

Today, with the return to traditional values, blue also has regained recognition as messenger of the ancient culture of the Middle Kingdom on the jackets donated to foreign heads of state who participated to the APEC in 2001.

GREEN IN MEDICINE AND ALCHEMY

The theory of the five elements associates green-blue to wood, east, liver and gallbladder, muscles, tendons, eyes, tears, the sour taste, anger and spring. Wood as Wilfried Rappenecker writes, is green in its coloured form and is liver as organ in the body, "the taste is sour and the smell is sour-rancid; the climatic factor is wind, the stage of life are childhood and youth. Life, which according to Chinese traditional medicine follows the seasons and the five directions, begins therefore with green, with the wood element and unfolds from east to west carrying within it a part of shadow as well as of light.

The liver like all other inner organs was object of empowerment through practices of inner alchemy (*neidan)* and outer alchemy (*waidan)* that took hold in China around II sec. BCE, practics aimed at gaining immortality or 'long life' employing various potions and meditative techniques among which the visualisation of the 'breaths'.

In the *Huang tng jing,* - the daoist treatise of inner alchemy, which probes lifestyle, nutrition, sexuality and the development of energy - each inner organ is linked to its own 'breath' and is inhabited by a 'god' who can be evoked and visualised through precise meditation exercises, in the form of coloured 'breath'. In such a way in some texts one finds that the liver is inhabited by a green youth who governs the *hun* and *po* spirits who presides over life, while in others takes on the form of a green-blue dragon (*Qing*) and its 'breath' rises and grows, circulates freely and without pause in every direction. When it is in balance, it is harmonizing and warm like spring and sends blood to muscles and tendons, making movement possible and helping the immune system.

CONCLUSION: GREEN TODEY

As I wrote at the start, today the term Qing is no longer used to define one of the basic colours. It remains a literary term rich with symbolic nuances; now different expressions are used for green and blue according to the shade such as Lǜ (green, saturated green); Bì (bluish green, turquoise); Căng (dark green, deep green); Cuì (emerald green); Lán (blue, azure); Shĕn lán (blue, deep azure).

In China also does Green, Lǜ, as a word and as a concept, begin to get used to indicate environmental consciousness of age old tradition which in recent years is being slowly rediscovered, so much so that a huge novelty has been introduced into the economic programme of the country: that of the 'Green GDP' which, as Federico Rampini reminds us, "should help to transform the culture of economic growth, finally taking into account the quality of growth too". It is a measure introduced in 2004 by Chinese prime minister Wen Jabao who proposed to consider a green gross domestic product in order to match economic growth with environmental consequences where risk to and loss of biodiversity and CO2 emissions are included in the parameters.

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The building to let in Lisbon, colour and identity

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ABSTRACT
The buildings to let shaped the image of the city. Their colours give them a specific identity. From the Gaioleiro building (1861-1930) until the modern building (c.1951-c.1960) colour palettes emerge given by the glazed tiles, which appeared in the façades and in the interior of the buildings, and the use of hydraulic mosaics (from the 1930s to the 1950s) and vitrified pastille (in the 1950s), combining the use of the Estado Novo's bland shade colours with a new set of vibrant colours. The colours and building materials associated to this period are elements that must be preserved on the rehabilitation and conservation of this heritage.

Keywords: *Building to let, regulation, building materials, colour palette, identity*

A TYPOLOGY OF BUILDING A CITY OF TENANTS

Since king D. Manuel I, the architecture was defined by the Crown and the Senate of the City, resulting in a precise and theorized corpus of laws concerning architectonic polices, which defined Lisbon's image, and the image of the Portuguese territories. From the 16th to the 1st half of the 18th century, the division of the city's spare land in urban plots correlates to careful planning of the area and to the appearance of an organizational pattern of a multi-family building: the building to let. Between the first half of 16th century and 1960s different models of building to let emerged in Portugal: the *stone and lime* building, the *Pombalino* building, the *gaioleiro* building, the *Estado Novo* building and the *modern* building (Matos 2003; 2009 and 2018). The designation *building to let* (in Portuguese, *edifício de rendimento*) was firstly used by Carita (1994) in his work on Bairro Alto, where he tried to trace the origins of this typology: *The Pombalino period, for the first time, establishes an erudite reference model for the building to let. Until then the palace was the only model of the civil architecture, but its symbolism prevented it from functioning as a reference model, with few exceptions, and may only be conceived as a diffuser of trends.* (Carita, 1994, p. 124). The data set by Carita (1999) for the *Manuelino* Lisbon urbanism helped us to draw, for the first time, the picture of the building to let from its origins until the 1st half of the 18th century

(Matos 2003). In the 20th century the buildings to let presented to the Municipality of Lisbon were referred as *prédio de rendimento* that is, *property for renting or letting*. Considering that *prédio*, means either urban property or rustic property (a land), we kept the designation employed by Carita in 1994 (Matos 2009; Matos 2018).

In the 1950s, 1960s and 1970s, letting dwellings predominated in the city. The Horizontal Property Act, Decree 40 333, 14 October 1955, would permit to pass from a tenants city to an owners of dwellings city. Embryonic credit and saving regimes were created for acquisition of dwellings, made by *Caixa Geral de Depósitos* and *Crédito e Previdência*, which target a very selected population. From 1976 onward a political inflection occurred: the credit for dwelling acquisition with government-subsidized loan was created. The investment focused on the building to let gave place to the investment centered on the promotion of the dwelling for sale. The city of landlords and tenants would give place to the city of the financial institutions and owners with debts (Silva Nunes, 2005). However, the typology of a building vertical organized for different families would stay and evolve until the present.

AN IMAGE OF THE BUILDING TO LET, PRECISING COLOUR PALETTES

The buildings to let shaped the image of the city. Their colours give them a specific identity. From the Gaioleiro building (1861-1930) until the modern building (c.1951-c.1960) the regulations defined aspects of the façades, dwellings, building materials and, colour palettes to be applied to finishing details. From this study emerges a list of elements that must be preserved on the rehabilitation and conservation of this heritage.

The notarial register of 5th August, 1861 sets the appearance of the Gaioleiro building, when a new model of staircase emerged and ends in 1930, when the General Regulation of the Urban Construction for the City of Lisbon was approved. In 1869 the colours and building materials are specified: *the staircase would be in modern style of curved pieces of woods; the entrance would be paved in black and white stone in a chessboard pattern; the first step would be in squared stone as the arch.*

The notarial register of 1863 shows the free use of colours in the doors and door-posts. Apart from white, other colours, including orange, could be used, as pleased the owner. In 1866 the rooms were lined with wallpaper tile.

Figure 1: Rua da Imprensa Nacional 96, detail of the glazed tiles.

From 1850 onwards, the revetment of the façades with glazed tiles became current (Carvalho, 1997). They are a reflex of the romantic Lisbon (Silva, 1997). The embossed glazed tiles in their bas and full embossed version would make their appearance in the 2^{nd} half of the 19th century. The buildings referred bellow are examples of façades with glazed tiles in the turn of the 20th century: Rua do Poço dos Negros 147, Rua do Poço dos Negros 105-107, Rua da Imprensa Nacional 96; Rua da Imprensa Nacional 40, Rua da Imprensa Nacional 36-38, Rua Marcos Portugal 59-61, Rua Gustavo Matos Sequeira 18-36, Praça do Príncipe Real 1/ Rua do Século 171, Avenida D Carlos I 82, Avenida D Carlos I 108, Rua Silva Carvalho 118-122, Rua Silva Carvalho 124-126. The glaze tiles on façades of Rua do Vale do Pereiro 2/Rua do Salitre 132(1949) Rua Conde Rendondo 20-20B (1956) attest the evolution and renovation that the glazed tiles would undergo.

The 1930's Regulation, active until 1951, established bland shade colours for the façades. Within this norm the colours could vary from different tones of pink, grey, blue, cream-coloured, yellow, green and were applied to modernist and Estado-Novo buildings. The rose tones dominate in the monumental Areeiro urban complex. In Rua do Salitre, Rua Sousa Viterbo (Bairro Lopes), which were non-monumental areas, a variety of colours was used. In Rua D. João V axis, an Estado-Novo urban complex with some monumentality, rose tones and a variety of bland shade colours were applied.

Figure 2: Rua D. João V even numbers.

The descriptive memory of Carlos Mardel 106 (1939) helps to precise the colour palette of Estado-Novo interiors. In all the floors of the dwellings the floors would be in pine wood in British floor style. The floors of the kitchens and bathrooms would be made in hydraulic mosaics or in other building material suitable and approved by the municipal inspection. Their walls would have glazed tiles, with no decorations, until the height of the doors and from that until the ceiling would be painted using an enamel paint. Each kitchen would be a kitchen sink made of withe limestone, a waste sink made of limestone, and a closet. The pantries would have shelves. The roof will be in Portuguese roof-tile, with eaves in Portuguese style. The structure of the roof would be made in pine wood.

According to the 7^{th} edition of the 1930's Regulation the garnishing of the exterior openings, when not in concrete or squared stone, could be in stone masonry or solid brick. This norm would constitute a path to modernity as can be seen in Rua de São Marçal 176 (1944-project, 1947-ampliation) and in Avenida da República 36-36F (1948), where the solid brick stands out as a strong red, full of modernity. This building material would be later used in Costa Cabral Block

(1953-1955), in Oporto and also in 1950s, in the big urban interventions in Lisbon, in Olivais, where it would play a major role in Rua Sargento Armando Monteiro Ferreira (1959-1968), Rua Cidade da Beira, Rua Cidade de João Belo (1969), thus becoming a building material associated to the Portuguese Modern Movement. The MG building (1959-1960, 1961-1968), in Rua Júlio Dinis, in Oporto, using red ceramic brick, with an organicity and materiality of Scharoun or Aalto, would symbolize the final expression of this building material in the building to let.

Figure 3: Avenida da República 36-36F.

The 1951's Regulation defined that the quality and nature of the building materials applied to any building should assure the more adequate salubriousness and aesthetic conditions to the use of the building. The use of new building materials or construction techniques would imply an approval by the Laboratory of Civil Engineer. The free use of colours and building materials, legislated by the 1951's Regulation, are illustrated by the modern buildings in Praça das Águas Livres 8-8I/Rua Gorgel de Amaral 1-1A, Calçada Engenheiro Miguel Pais 42, Rua da Imprensa Nacional 64-64D/Rua Marcos Portugal 91-91D, which are buildings in the historical city. In Praça das Águas Livres 8-8I/Rua Gorgel de Amaral 1-1A the revetment materials, as well as everything else in the building, were carefully chosen. In this building were used painted plaster, carpentries in varnished tola wood, vitrified pastille, hydraulic mosaic. The colours in the façades are bland shade colours: yellow, pink, grey, blue and a soft brown. Regarding Rua da Imprensa Nacional 64-64D/Rua Marcos Portugal 91-91D, the colour palette of its descriptive memory let us know that, in the interiors of the dwellings, in the living room and bedrooms, the floor would be in parquet, and in the service areas, the floors would be in hydraulic mosaics and the walls would have glazed tiles until 2.00m above the floor; the walls and ceilings would be plastered. The colours used in the façades are bland shade colours, and black, soft brown, white and yellow. In the façades it was used vitrified pastille, mostly in the ground floor and in the corner of the building, combined with plastered surfaces, in the majority of dwellings floors. In Calçada Engenheiro Miguel Pais 42, the tridimensional glazed tiles in a strong and vibrant colour are fundamental in the construction of the façade of this small building, which contrast with the use of the withe as main colour of the façade and blue limestone in the ground floor, marking the entrance to the building. The colour palettes of these buildings help to construct the image of the Lisbon of the epoch.

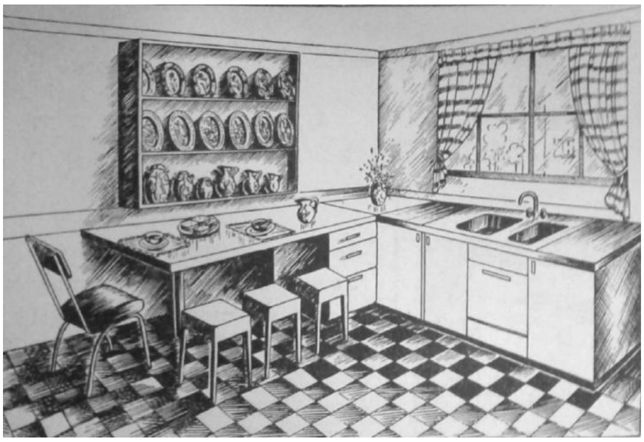

Figure 4: modern kitchen of Laura Santos' book showing building materials referred in the descriptive memories of Estado Novo buildings.

Figure 5: Calçada Engenheiro Miguel Pais 42, detail of the tridimensional glazed tiles.

CONCLUSION

From the Gaioleiro building until the Modern building there is a transformation made of rupture and continuation. The glazed tiles evolved and gained protagonism and tridimensinality. The 1951 Regulation permitted freedom of building materials and colours but changes do not occur in a fast pace, the hydraulic mosaic was still an option as well as the use of the bland shade colours, used in harmony with more vibrant colours and the vitrified pastille. The usage of red brick in the façades, applied in Avenida da República 36-36F, would be seen in the big urban interventions in Olivais playing a major role, becoming a building material associated to the Portuguese Modern Movement.

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colour & human comfort

Human well-being: A contrastive analysis of phraseological units with colours in Albanian and German[1]

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ABSTRACT

After introducing the theoretical approach and the interlingual reference analysis model, this paper studies contrastively some Albanian and German phraseologisms with colour naming components related to positive states of being such as good and goodness, success, generosity, honesty, etc. The aim of this article is to identify symbolical, cultural and linguistic equivalences and differences in Albanian and German colour multi-word units.

Keywords: *contrastive analysis, colour, phraseology, Albanian, German*

INTRODUCTION

Well-being means "the state of being comfortable, healthy, or happy[2]". This positive condition is expressed not only by simple lexical units (lexemes) such as fortune, prosperity, prosperousness, success, successfulness, health, happiness, joy, comfort, good, success, advantage, benefit, satisfaction, etc.[3], but also by multi-word units (phraseologisms). The present paper compares colour symbolism in Albanian and German from a phraseological point of view.

Phraseology is the discipline of the fixed phrases that in system and sentence function and mean as single words (lexemes) (Palm 1997:1). Also, Gries (2008:6) states that a phraseologism "functions as one semantic unit", namely as a single lexical unit. Consequently, phraseological units are phrasemes or idioms composed of at least two lexemes, that is words (Palm 1997: 2). These multi-word units are polylexical, reproducible and have stable and idiomatic structures (see

[1] This paper is part of the initial findings of an ongoing PhD research project entitled "Farbphraseologismen Albanisch-Deutsch kontrastiv" (Contrastive analysis of colour phraseologisms between Albanian and German), tutor Prof. Dr. Peggy Katelhön.

[2] https://en.oxforddictionaries.com/definition/well-being (Accessed 20.05.2018).

[3] https://www.merriam-webster.com/thesaurus/well-being (Accessed 20.05.2018).

Burger 2007; Dobrovol'skij, Piirainen 2002; Kahl 2015). Among different types of phraseologisms, this short article focuses on *Farbphraseologismen* (see Wanzeck 2003), that is multi-word units with colour naming component as a key element.

THEORY

The brief theoretical framework presented in this paper provides a concise summary, being here the space limited. The reference analysis model for the Albanian-German language pair is that of interlingual equivalence which is divided into three categories: full (=), partial (±) and zero (ø) equivalence, based on a) general phraseological meaning, b) literal meaning, and c) syntactic structure (Kahl 2015:122).

The contrastive analysis is built on the cognitive approach, being cognitive linguistics "interested in knowledge *through* the language" (Geeraerts, Cuyckens 2007:6). In this perspective, "linguistic knowledge involves not just knowledge of the language, but knowledge of the world as mediated by the language" (Geeraerts, Cuyckens 2007:7). Consequently, being CL usage-based (Kristiansen, Achard, Dirven, Ruiz de Mendoza Ibáñez 2006:2), it studies formal language structures not as autonomous but as "reflections of general conceptual organization, categorization principles, processing mechanisms and experiential and environmental influences" (Geeraerts, Cuyckens 2007:3). Among all the domains of cognitive linguistics, we are in the field of cognitive sociolinguistics, which "combines the use-based CL tenet with fine-grained research on language variation and examines the correlations with cognitive models, now widened as cultural models" (Kristiansen, Achard, Dirven, Ruiz de Mendoza Ibáñez 2006:14). On these assumptions, taking into consideration also the pluricentric character of both languages (Clyne 1992, Muhr 2016, Muco 2018), phraseological units containing colour denominations will be studied as cognitive and sociolinguistic varieties.

Turning now to the role of colour in phraseological units, Wanzeck (2003:25) states that colour has a symbolic function and the symbolism of colours is composed of cultural symbols and linguistic symbols. The linguistic symbol manifests itself in the form of a word and many linguistic symbols are based on cultural symbols (Wanzeck 2003:25; see also Dobrovol'skij, Piirainen 2002:227-284). Linguistic symbols without a cultural and historical background are characterized by the fact that their symbolism occurs exclusively in fixed compounds such as *etwas in rosarotem Licht sehen*, "to see everything through rose-tinted light", that means to judge something very positively (Wanzeck 2003:26). Moreover, there are also linguistic symbols that are based on cultural symbols and metaphors, such as *jmd. den roten Teppich ausrollen*, "to roll out the red carpet for someone", that means 'to receive someone with the utmost honour'. So, the red colour brings in this context the cultural-symbolic meaning of 'importance', and the metaphor manifests itself in knowing that a red carpet is unrolled in high-level state receptions (Wanzeck 2003:26). This implies that figurative concepts and meanings are a fundamental characteristic of phraseological units. According to Lakoff und Johnsen (2003:115) "metaphor pervades our normal conceptual system. Because so many of the concepts that are important to us are either abstract or not clearly delineated in our experience (the emotions, ideas, time, etc.), we need to get a grasp by means of other concepts that we understand in clearer terms (spatial orientations, objects, etc.). This need leads to metaphorical definition in our conceptual system (Lakoff, Johnsen 2003:115)".

Agnello, who has deeply studied the symbolic function of colours, states that colour is above all a phenomenon linked to factors such as cognition and culture, forms of knowledge, social environments, individual and collective knowledge, anthropological structures (Agnello 2013:11). In addition, according to the semiotic mechanism, Agnello (2013) offers another argument saying that colours are not symbolic, but semi-symbolic. This means that their symbolism is in opposition to that of other colours. So, each colour is always in relation, at least, to another diametrically opposed colour (Agnello 2013:68).

CONTRASTIVE ANALYSIS

Before addressing the interlinguistic comparison in detail, the data for the contrastive analysis were collected from Albanian-German dictionaries and corpora. Albanian colour phraseologisms were selected from *Fjalori frazeologjik i gjuhës shqipe* and *Fjalori i shqipes së sotme* and Albanian National Corpus. The multi-word units for the German language were extracted from *Redewendungen – Wörterbuch der deutschen Idiomatik*, *Redensarten-Index* and *Das Deutsche Referenzkorpus–DeReKo*. In addition to the abovementioned symbols used to indicate the equivalence, the symbol "---" is used below as a sign of 'no phraseological unit'. Let us now look at the analysed phraseologisms:

(1a) Albanian: ---

(1b) German: *etwas in rosarotem Licht sehen*, "to see everything through rose-tinted light", that means 'to judge something (uncritically) very positively', 'to judge something overly positive/optimistic'; 'to see a thing from the good side'. And *etw. durch die rosa [rote] Brille sehen*, "to see everything through rose-tinted [red-tinted] glasses".

zero (ø) equivalence

(2a) Albanian: *të shtrosh tapetin e kuq per dikë / të shtrosh tepihun e kuq per dikë*[4], "to lay down the red carpet for someone" that means 'to receive a guest with the highest honours'.

(2b) German: *jmd. den roten Teppich ausrollen,* "to roll out the red carpet for someone" that means 'to receive a guest with the highest honours'.

full (=) equivalence

(3a) Albanian: *e ka zemrën të artë / e ka zemrën flori*, "he/she has a golden heart", that means 'to be a very good, generous, loving and righteous person'.

(3c) German: *ein goldenes Herz haben*, "to have a golden heart", that means 'to be generous, benevolent and good natured'.

full (=) equivalence

(4a) Albanian: *e ka zemrën të bardhë*, "he/she has a white heart", that means 'to be good, generous'.

(4b) German: *ein reines Herz haben*, "to have a clean/pure heart", that means 'to be benevolent, magnanimous'.

partial (±) equivalence

(5a) Albanian: ---

(5b) German: *eine weiße Weste haben*, "to have a white vest", that means "to be honest, pure". Its variants are: *eine saubere/reine Weste haben*, "to have a clean/pure vest".

zero (ø) equivalence

(6a) Albanian: *syri i bardhë si një kokërr dardhë*, "the white eye as a pear". This expression means that 'you can understand if someone is gentle and kind-hearted by looking into his/her eyes'.

(6b) German: ---

[4] Sociolinguistic variety, for more information see "Regionale Differenzen" in Burger H. 2003, 195-213 pp.

zero (ø) equivalence

(7a) Albanian: *të japësh/të marrëshdritën jeshile; të japësh/të marrësh dritën e gjelbër*[5], *"*to give/get the green light".

(7b) German: *grünes Licht geben/haben*, *"*to give/get the green light". In both languages these expressions mean 'to receive permission to proceed with some action or task and allow somebody to begin something'[6].

full (=) equivalence

According to Agnello's semi-symbolic reasoning, comparing above-listed colour phraseologisms with positive meanings to the following conceptually opposed, it is evident that:

"WHITE : BLACK = GOOD : BAD"[7] → in Albanian *e ka zemrën të bardhë,* "he/she has a white heart", is in opposition to *e ka zemrën të zezë*, "he/she has a black heart", that is "to be bad, bad-hearted"; in German *eine weiße/saubere/reine Weste haben*, "to have a white/clean/pure vest" is in opposition to *dunkle/schwarze Flecken auf der Weste haben*, "to have dark/black spots on the vest", and *einen dunklen/schwarzen Fleck auf der Weste haben*, "to have a dark/black spot on the vest", that is 'to have done something immoral, unlawful'.

"GOLD : BLACK = GOOD : BAD" → in Albanian e *ka zemrën të artë/e ka zemrën flori*, "he/she has a golden heart", is opposed to *e ka zemrën të zezë*, "he/she has a black heart"; in German *ein goldenes Herz haben*, "to have a golden heart", is opposed to *ein reines Herz haben*, "to have a clean/pure heart".

"PINK/RED : BLACK = OPTIMISM : PESSIMISM" → in German *etw. durch die rosa [rote] Brille sehen*, "to see everything through rose-tinted [red-tinted] glasses", is contrary to *alles durch die schwarze Brille sehen*, "to see something through black-tinted glasses"; in Albanian exists the pessimistic phraseologism *e sheh me syze të errëta (diçka)*, "he/she sees (something) through dark-/black-tinted glasses".

"GREEN : RED = PERMISSION : DENIAL" → in Albanian *të japësh / të marrësh dritën jeshile; të japësh / të marrësh dritën e gjelbër*, *"*to give/get the green light", opposes to *të japësh / të marrësh dritën e kuqe*, *"*to give/get the red light"; in German *grünes Licht geben/haben*, *"*to give/get the green light", opposes to *rotes Licht geben/haben*, "to give/get the red light". Clearly, this figurative meaning derives from the function of the common traffic lights.

CONCLUSION

This work does not pretend to be exhaustive but to provide some Albanian and German examples of contrastive phraseological analysis. The analysed phraseological units show that: three of them are zero (ø) equivalence cases; three full (=) equivalence and one partial (±) equivalence. The meaning of the colours depends on the opposition with other colours. Black and white/gold are opposed colours, because black has a negative connotation and white/gold a positive one. For this reason, in the abovementioned Albanian phraseologisms white and gold can be used as synonyms. Another pair of opposed colours is composed by green and red, according to the opposition of the same colours used in the traffic lights to indicate permission to cross or pass the road (green light) and to stop (red light). According to the given examples, the red colour has both a negative and a positive connotation. In addition, the analysed phraseological units present varieties, two examples of these are sociolinguistic varieties. As it is evident, Albanian and German seem to have

[5] Sociolinguistic variety, for more information see "Regionale Differenzen" in Burger H. 2003, 195-213 pp.

[6] https://idioms.thefreedictionary.com/get+the+green+light (Accessed 24.05.2018).

[7] Also Dobrovol'skij and Piirainen (2002:244-245) consider white and black as pair of contrasting colours.

common semi-symbolic use of colour pairs in the well-being multi-word units. In conclusion, colours can have different figurative meanings based on sociocultural context and (con)textual usage.

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Visible Dispersion in Negative-Index materials: a Photorealistic Spectral Rendering approach

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ABSTRACT

Using a free open source ray tracing program, photorealistic spectral images have been developed of how several simple optical elements, such as prisms and lenses, would appear in the real world if they had been made with materials with negative index of refraction (metamaterials). Surprising and educationally useful results have been obtained with the aim of providing with a visual interpretation of the atypical behavior of negative-index materials, and a look at dispersion in the visible range in such optical elements.

Keywords: *Spectral rendering, Metamaterials, Geometric optics, Dispersion, Education*

INTRODUCTION

In an isotropic material, its refractive index *(n)* can be defined in terms of its relative dielectric permittivity *(ε_r)* and its relative magnetic permeability *(μ_r)* as $= \sqrt{\varepsilon_r \cdot \mu_r}$. In general, ε_r and μ_r are complex numbers, whose imaginary parts account for the losses of the material. To simplify, we will assume that the losses are negligible and therefore the parameters are real. As the typical transparent materials have positive ε_r and μ_r, the positive square root is used for *n* by convention, but a simultaneous change in the sign of ε_r and μ_r has no effect on the equation. Veselago (1968) inferred that the existence of materials with simultaneously negative ε_r and μ_r implied that the refractive index of such material would be negative. At that time the proposal was only a thought experiment, but recent studies have shown the feasibility of engineering metamaterials with this property (Smith, *et al*., 2004; Shalaev, *et al*., 2005). The vast majority of these metamaterials have been demonstrated at frequencies ranging from microwave to infrared, and recent results have been achieved in the visible region (Grigorenko, *et al*., 2005; Ishikawa, *et al*., 2005).

Subsequently, several researchers developed photorealistic images of isotropic materials with negative refractive index at visible frequencies using POV-Ray (2017), an open-source raytracer, with the aim of helping to get an intuition and visual understanding of metamaterials, with surprising and pedagogically useful results (Dolling, *et al*., 2006; Courtial & Nelson, 2008; Danner, 2010; Naranjo-Correa, *et al*., 2017). In addition, our research group has extensive experience in the use of POV-Ray for optics and colour teaching (Martínez-Borreguero, *et al*., 2011; Martínez-Borreguero, *et al*., 2016; Naranjo-Correa, *et al*., 2017). The goal of this paper is to add to these previous works, focusing on light dispersion. To this end, photorealistic spectral images were made of light passing through optical elements with negative index of refraction.

EXPERIMENTAL

The use of POV-Ray to render photorealistic images of materials with negative index of refraction has been validated in previous studies, but unfortunately the program does not perform spectral calculations. Instead of computing and storing light intensities for every wavelength, POV-Ray uses an additive representation of colour of only three values (RGB), which saves both computing time and memory. However, this method introduces colour distortion and produces physically incorrect images, which is a main disadvantage when working with simulations involving dispersion.

All materials, however, have unique spectral responses; thus, in order to provide fully correct colorimetric results, all calculations should be done wavelength by wavelength. In order to do so, a workaround was implemented (Wahler, 2013), so that the program could be used as a spectral rendering engine. It works by rendering a set of grayscale images, each representing a specific wavelength. The output is a set of 36 high dynamic-range images representing the wavelengths from 380 to 730 nm in steps of 10 nm. The 36 images are finally combined and converted to tristimulus values at the very last step of the calculation using the CIE colour matching function.

The refractive indexes in POV-Ray spectral rendering are calculated using the Sellmeier equation, where B_i and C_i are experimentally determined:

$$n^2(\lambda) = 1 + \frac{B_1\lambda^2}{\lambda^2 - C_1} + \frac{B_2\lambda^2}{\lambda^2 - C_2} + \frac{B_3\lambda^2}{\lambda^2 - C_3} \quad (1)$$

To determine n, we calculate the square root of the right-hand side. Normally, the positive root is used to obtain the index of refraction, but in our case we use the negative root to define the refractive index of simulated metamaterials. Thus, from each real material we obtain its corresponding metamaterial in terms of n.

RESULTS AND DISCUSSION

In the following paragraphs, we will discuss how a beam of white light (CIE Standard Illuminant D65) is dispersed by the different optical elements.

If we use a metaprism made of N-SF11-M glass (the M denotes a negative refractive index) we obtain what we see in Figure 3 (top). The most striking aspect is the large deviation of the emerging beam, as it drastically changes its direction. Figure 3 (bottom) contains a detailed depiction of the trajectory of the rays. If we want the beam to reach the AC side and “go through” the prism in the usual way, we must change the sign of the angle of incidence θ_1 with respect to that of a normal prism.

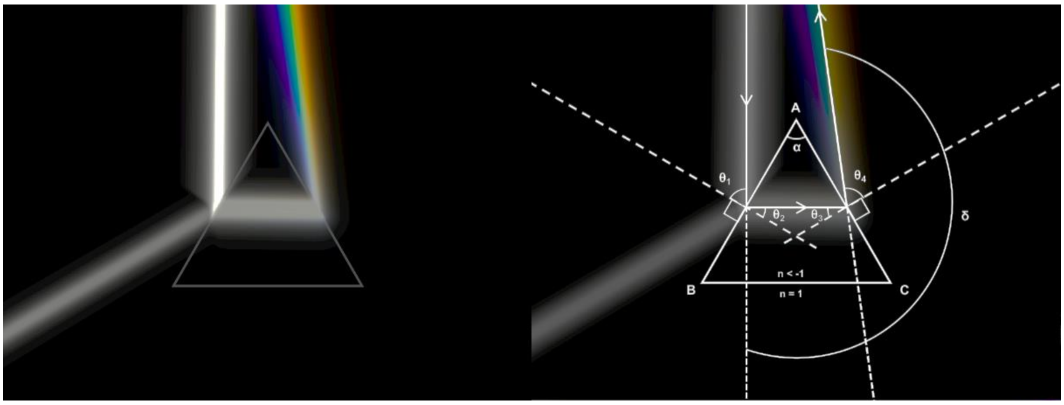

Figure 1: A beam of white light dispersed by an equilateral metaprism (left) and its diagram of rays (right).

If the dispersion is examined, it can be observed an analogous dispersion to that of a normal prism, except for the inversion of the exit angle. For visible light, in most transparent materials the refractive index decreases with increasing wavelength (normal dispersion). If the refractive index increases with increasing wavelength the material shows anomalous dispersion. In accordance with that definition, an anomalous dispersion may have been expected in our metaprism. However, the way in which we have defined the refractive index of our metamaterials implies a normal dispersion. In both cases the shortest wavelength is bent more strongly than the longest wavelength beam.

Figure 2 shows a N-SF11 prism (top of the dashed line) and a N-SF11-M metaprism (bottom of the dashed line) of an Abbe prism. These prisms are normally used to separate a single wavelength from a multiple wavelengths light beam. In our arrangement the beam of white light is perpendicular to the hypotenuse, so the beam only refracts when leaving the system, allowing a more direct comparison. In both cases, the angle θ_3 when exiting the prism is $\theta_3 = 30°$. For $\lambda = 580$ nm, $\theta_4 = 63.25°$ (prism) and $\theta_4 = -63.25°$ (metaprism). Again, blue light is bent more strongly than red light.

Figure 3 depicts a N-SF11 Littrow prism (top) and a N-SF11-M Littrow metaprism (bottom). Littrow prism are retro-reflecting dispersing prisms and, in our simulations, they are based on Abbe prisms with a reflective coating on the surface opposite the 60° angle. The angle of incidence is chosen to obtain minimal deviation. Again, in order to obtain minimal deviation in the metaprism, the incidence angle must be inversed with respect to the normal.

Lastly, Figure 4 shows two N-SF11-M metalenses, biconvex (top) and biconcave (bottom). In a normal binconvex lens, the beams of light passing through it converge to the focus behind the lens. However, when we use a negative-index material (top), the beams of light passing through it are spread, so we obtain a negative or diverging lens. Likewise, in a normal biconcave lens the beams of light passing through it diverge, but if the lens is made with a negative-index material (bottom) it results in a positive lens, where the light beams converge to a focus behind the lens. As in their real counterparts, we observe spherical aberration, as beams distant from the lens axis are focused in a slightly different place than beams close to the axis. If we consider dispersive effects, we can also see chromatic aberration, as light of different wavelengths is focused to different positions. The effect is greater the further we move away from the optical axis, and coloured fringes are seen at the edges of the more distant beams.

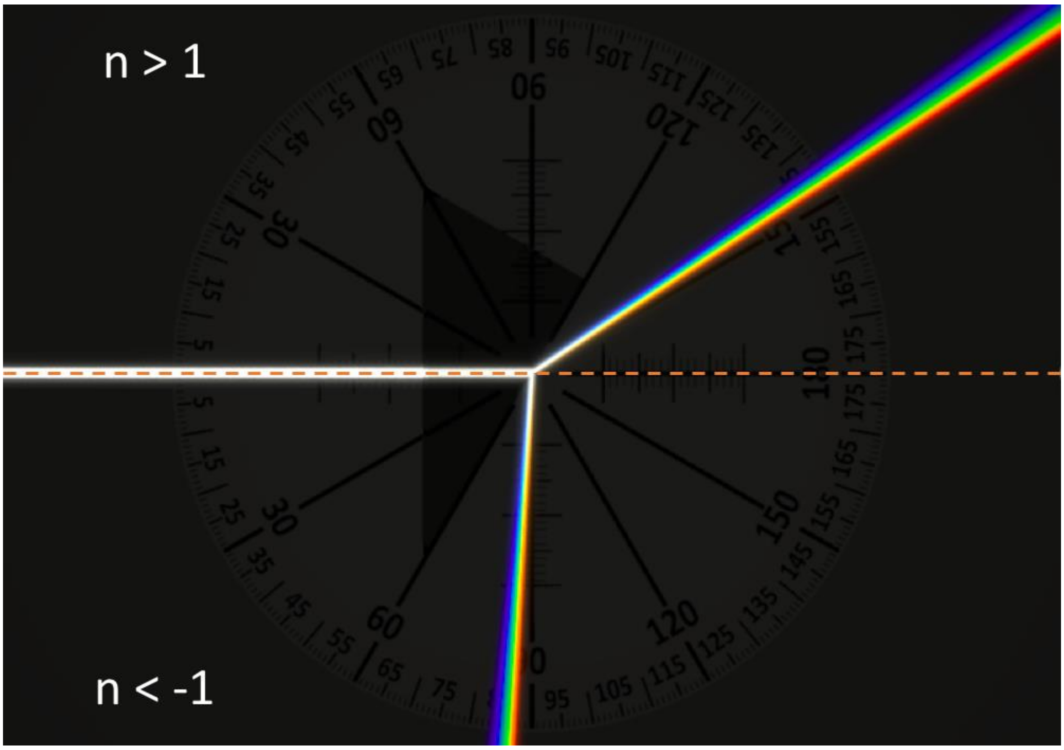

Figure 2: Abbe prism (top) and metaprism (right) with a white beam impinging at θ1 = 0°.

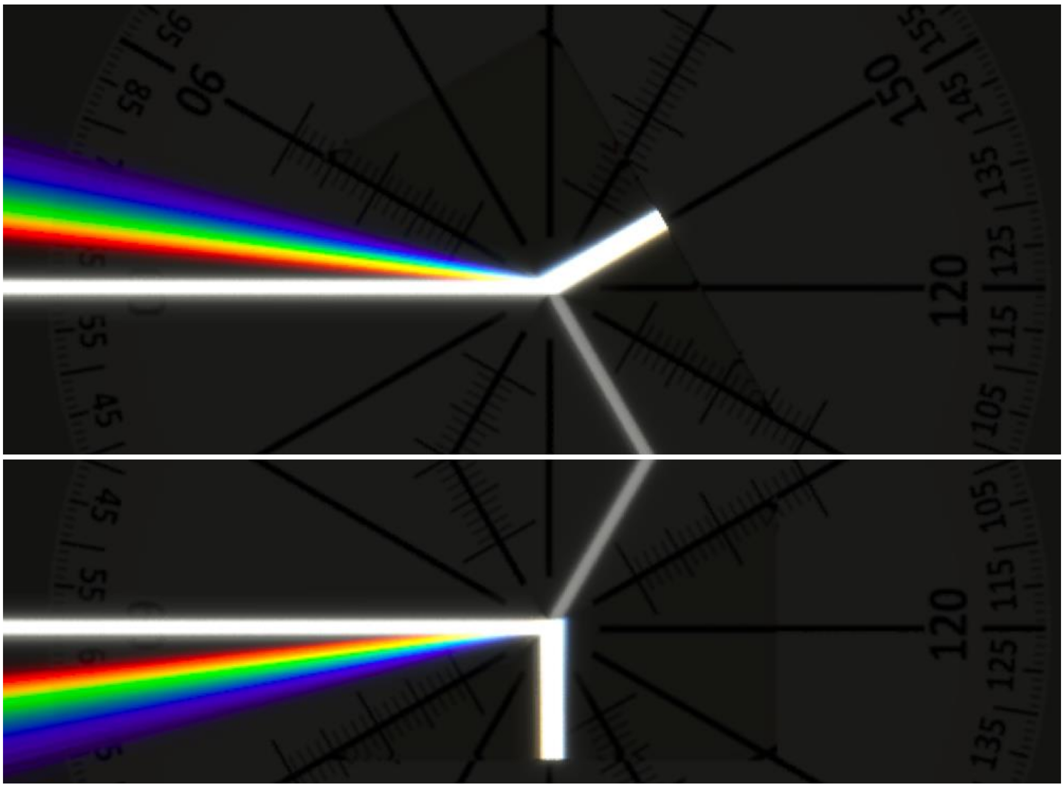

Figure 3: Minimum deviation in Littrow prism (top) and metaprism (bottom).

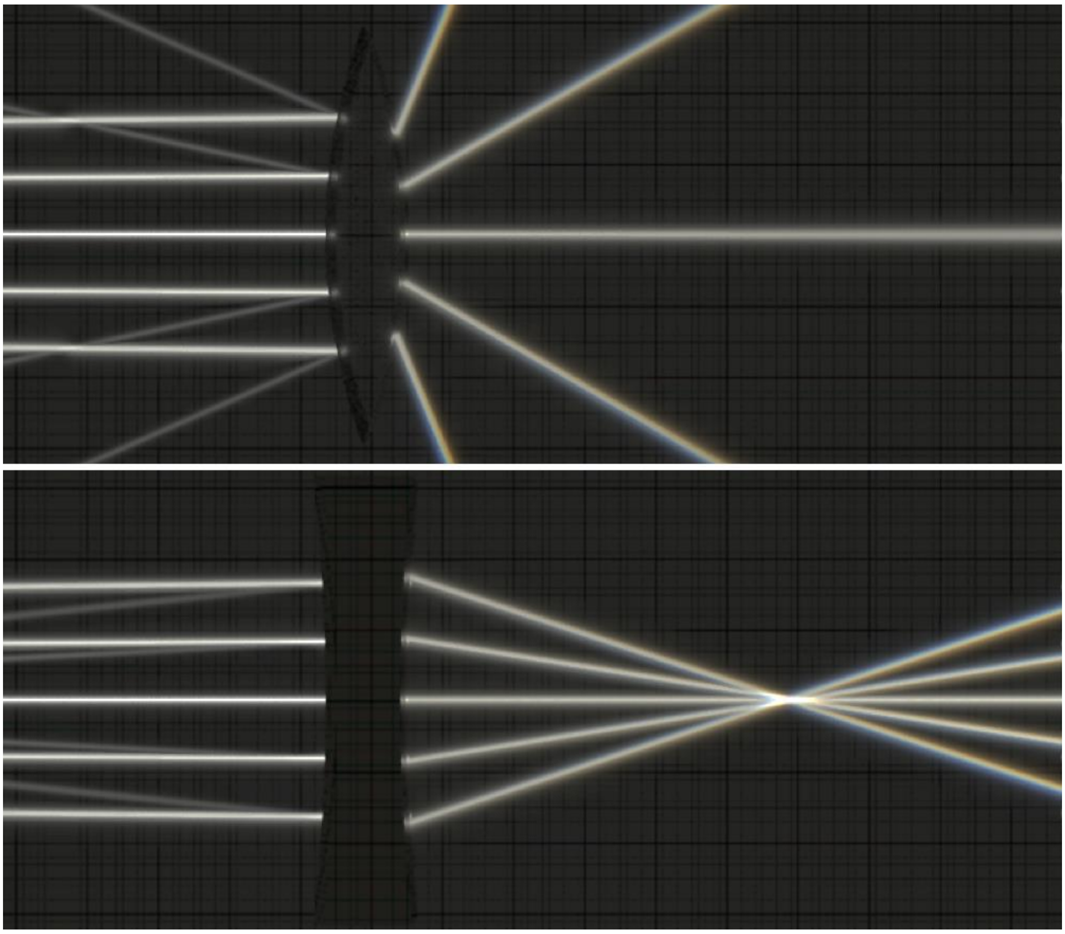

Figure 4: Biconvex negative metalens (top) and biconcave positive metalens (bottom).

CONCLUSION

Several examples of photorealistic images of optical elements made with negative-index materials have been presented. The images were generated using an open source ray tracing program adapted to render multispectral images. The images presented raise several questions of great educational value, and they provide a visual interpretation of the striking behavior of simple optical elements made with negative-index materials, and how dispersion in such objects would look in the visible domain.

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The Colour of the Sky: from the Cyanometer to Architecture

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ABSTRACT

From the most distant Eras of mankind's history, the human being has always marvelled at the beauty of the "blueness" of the space above him. That intangible matter gave rise to one of the oldest and continuing struggles in colour history: to be able to capture that hue; that feeling of *spatium*; of infinity.

In the 18th century, Swiss physicist Horace-Bénédict de Saussure invented a device to measure the "blueness" of the sky - the Cyanometer.

Guided by the curiosity about the Cyanometer's principles and their possible applications to Colour Studies in Architecture, I have led the students on a research concerning the registration, in NCS (Natural Colour System) samples, of the variation of the sky's colour, and the creation of a contemporary Cyanometer.

The observation results pointed to colours ranging from light to medium tones (05% to 40% of Blackness) and also to light and medium saturated colours (05% to 60% of Chromaticness). The colours of the sky at North were always darker and more saturated than at the other cardinal points, at the same hour. But the most surprising results were related to the Hue: in 85% of the observations, the colours were grouped into two colour families: R80B (Red with 80% of Blue) and R90B (Red with 90% of Blue). The conclusion is that the sky, leastwise in Portugal, always has a bit of Red mixed in with the Blue!

The paper will present the students' work, its conclusions and an application of the findings on a Colour Study for a school in Lisbon.

Keywords: *Cyanometer, Blue, Sky, Teaching, Architecture*

INTRODUCTION

The Sausure's Cyanometer was built to prove that the variations of the Blue in the sky were caused by the amount of water vapour in the atmosphere. Saussure painted 52 watercolour shades of Prussian Blue, from White to Black, in a circle that he held up to the zenith at a standard distance from the eye. The shade matching the colour of the sky established the degree of blue.

Figure 1: Horace Benedict de Saussure Cyanometer, 1760.

Later, German naturalist Alexander von Humboldt, asked Saussure for one of these devices and carried it with him on his voyages and explorations worldwide. When climbing the Chimborazo, Equador, at an altitude no one had before, he set a record for the darkest Blue: 46th on the scale of 53.

Of course, no one really knows what kind of Blue was that 46th Blue.

In fact, we do not know with accuracy, which blues did Saussure paint on the original colour scale of the Cyanometer, because of the time wear, or even if the two (or others) colour circles produced by Saussure were exactly similar.

If you search the Internet you will find some examples of different homemade scales to measure the Blueness of the sky, or even some artistic interpretations, with infinity of blue nuances, but without any rigor or possibility of comparing the results.

Noticing this variety, and lack of rigor, the first concern was to allow people from around the world to be able to measure their skies with the same referential. We choose NCS (Natural Colour System) samples for its worldwide diffusion and its rationale based on human perception.

FIELD WORK

The students found 142 different blues in the sky, amongst observations at different days and different hours. They directly compared the NCS samples with the colour of the sky.

Figure 2: Field Work.

After the first observations, with the NCS samples, students stated that they saw many Blues in the Sky. Afterwards, they established the main reasons for the sky's colour variation: geographical orientation and the hour of observation. One group of students also stated the importance of the observation angle. In fact, the colour samples of the original Sausurre's Cyanometer were to be observed only at the sky's zenith, but we found it interesting to compare the readings at different angles and orientations and see if there were any invariables.

Observation data:

Number of colour observations: 142

Time: from 10:00 a.m. to 06:00 p.m., in different days.

Site: Ajuda, Lisboa

Month: March

Note: diverse angles, four geographic bearings (N, S, E, W)

ANALYSIS

We obtained the following results (Fig.3) :

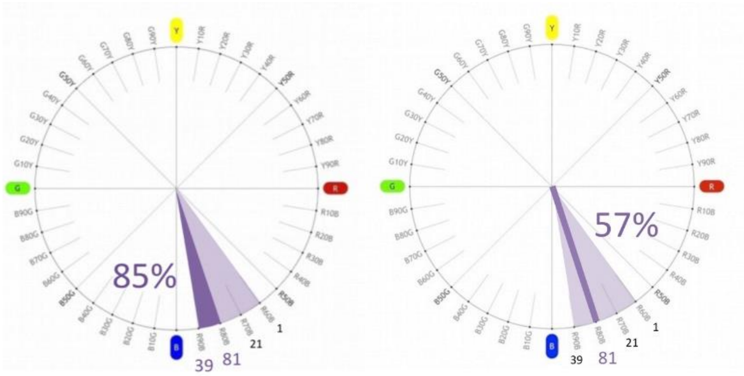

Figure 3: NCS Colour Circle. Hue Analysis.

All the observations range between R60B and R90B.

85% of all observations are included in two hues: R80B and R90B.

57% of all observations belong to R80B hue.

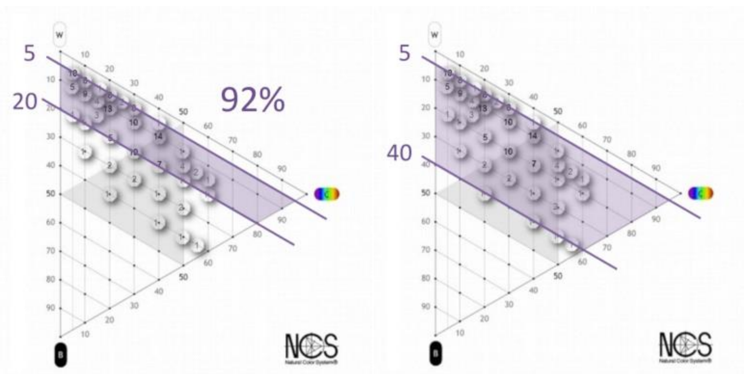

Figure 4: NCS Colour Triangle. Blackness analysis.

As you can observe on figure 4, the results pointed to colours ranging from light to medium tones (5% to 40% of Blackness).

130 observations out of 142 (92%) were situated between 5% and 20% Blackness

56 observations out of 142 (39%) were situated at 10% Blackness

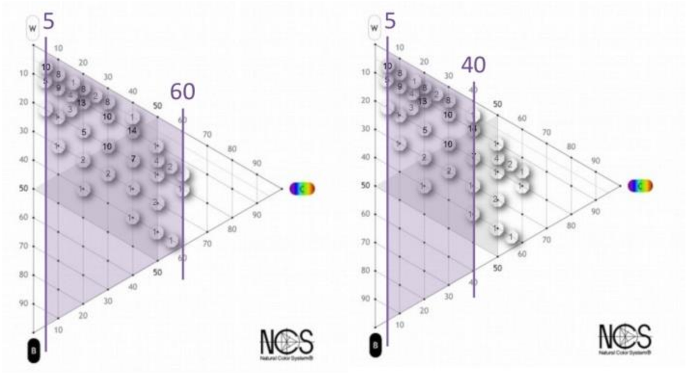

Figure 5: NCS Colour Triangle. Chromaticness analysis.

On figure 5 we analyze the Chromaticness results:

The observation results pointed to colours ranging from 05% to 60% of Chromaticness. 128 observations (90%) are between 05% and 40% of Chromaticness.

The students were encouraged to compare, analyze and describe their results through graphics, based on NCS system or related with the variation parameters that they found. Many graphics were produced. On Fig.6 we see an example of one group's observed colours at a given time and place (04:30 p.m. Ajuda, Lisbon), in relation with the geographic orientation.

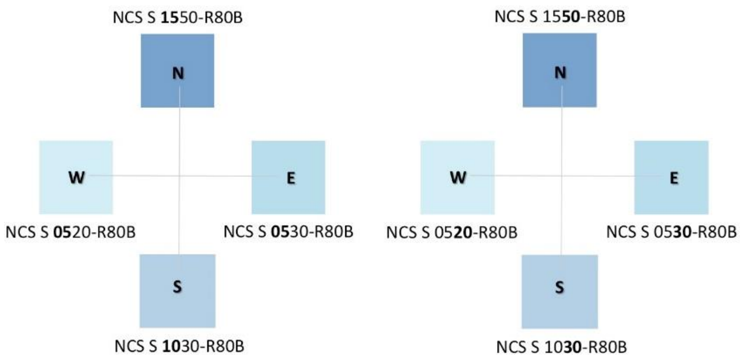

Figure 6: Colour variation due to geographic orientation. Blackness and Chromaticness.

The colours of the sky at North were darker than at the other cardinal points, at the same hour (15% Blackness to 5% and 19% on other cardinal points).

The colours of the sky at North were more chromatic than at the other cardinal points, at the same hour (50% Chromaticness to 20% and 30% on other cardinal points).

These observations were similar to all the others, revealing that the North sky always has darker and stronger colours (more chromatic).

CYANOMETERS

After they made the observations and the analysis, the final task for each group of students was to **create a *Cyanometer*** that could incorporate the results, and to be able to register the colour variation parameters, namely the **geographical orientation** and the **time of the observation**. For that purpose, they added a clock and a compass to the prototypes and one group included a process to measure the inclination angle through a
pendulum and a scale (last prototype on figure 8).

Figure 7: Developing the prototypes.

Figure 8: The Cyanometers built by the students.

APPLICATION IN A COLOUR STUDY FOR ARCHITECTURE

This knowledge about the colour of the sky was applied in a Colour Study for a College (Mira-Rio) in Lisbon. Blue was the institutional colour of the college and therefore we used it as a reference. On the South façade, we wanted to apply the colour Blue over the precast concrete shading elements, relating them to the colour of the sky. The results of our study pointed to use a Blue with 10% or 20% of Red, and since we are facing North when looking at the south facade, it should have a dark (less than 40%) and chromatic nuance (around 40%). We chose the colour notation NCS S 4040-R90B (fig.9).

Figure 9: The Blue of the sky.

The result was as expected and when the blue was applied we made a joke about the similarity with the colour of the sky. Translation: *João Nuno!* (the colour consultant) *You better come quickly! They already called the Fire Department because the Blue seems to be escaping to the Sky!*

CONCLUSIONS

We have studied the principles of the Cyanometer device, from the XVIII century, and created new prototypes based on sky observation and its colour variation.

From the observations, we determined three main parameters for the sky´s colour variation: inclination (angular distance from horizontal); hour of observation; and azimuth bearing. Students created their prototypes taking into account these findings.

The observation results showed us that the colour of the sky in all circumstances is a reddish blue (mainly R80B and R90B). The results were used in a colour study for architecture and proved their accuracy.

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Didactic of colour and contemporary art

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ABSTRACT
A didactic of colour that has strongly influenced several contemporary artists has been the one of Johannes Itten[1] (1888-1967). Today, in spite of some authors disputing his theory from a colorimetric standpoint, his method remains valid and is applied in the planning of visual and art projects and taught in many schools around the world. This work intends to analyse Itten's influence on the oeuvre of a group of Italian artists active in the Seventies, who publishing the manifesto *Astrazione oggettiva* (Objective Abstraction). They were: M. Cappelleti (1948), D. Mazzonelli (1943), G. Pellegrini (1953) and G. Wenter Marini (1944), gathered around the charismatic figures of the two senior artists: A. Schmid (1935) and L. Senesi (1938).

Keywords: *Colour, Itten's contrasts, Art, Astrazione Oggettiva group.*

INTRODUCTION

Many abstract painters in the Seventies took inspiration from the chromatic theory of Johannes Itten, published by the author in 1961 in his book *The Art of* Colour*: the subjective experience and objective rationale of* colour, elaborating their own personal applications and variations. Itten elaborates his own theory and organizes colours in charts for design purposes, establishing optical, formal and expressive laws for 7 distinct type of contrast, published in its first edition *The Art of* Colour*: The Subjective Experience and Objective Rationale of* Colour (1961). Values which painters of the *Objective Abstraction* group – object of this work –made their own.

The definition of Itten's so-called "complementary" gradation has elicited the criticism of some colorimetrists, who performed a spectrophotometric measurement of the hues indicated

[1] In 1919 the Swiss painter Johannes Itten (1888-1967) is summoned by Walter Gropius to set up the Bauhaus preliminary and compulsory course, whose objective is to provide the students with technical foundations and full control over the peculiarities of materials and colours. In1923 Itten leaves the Bauhaus and continues his activity as lecturer and painter in several European cites: in Berlin (Germany), in Krefeld (Germany), Zurich (Switzerland) and in Ulm (Germany), having an influence on generations of artists and lecturers.

by Itten, to verify scientifically the righteousness of their opposition and the accuracy of the contrast of quantity ratios (*The contrast of quantity in Itten's Theory: spectrophotometry for the verification of statements*. A. Di Tommaso, V. Garro, A. M. Gueli, S. Martusciello, M.D. Morelli, S. Pasquale). It is however necessary to keep in mind that paint's primary colours differ from the ones in colorimetric systems, and are: yellow, red (not magenta) and blue (not cyan). After all Itten himself clarifies that: "The colour theory exemplified here has *aesthetic purpose* and ensued from experience and from the way of seeing of a painter. What is essential for artists is the effects of colours and *not so much their physical characteristics, studied by chemists and scientists*."

ITTEN'S LESSON AND ART MOVEMENTS

The cultural context in which Johannes Itten's didactic of colour and lessons are received and elaborated, concerns artists who refuse figuration and focus on the pictorial language itself, particularly on the search for the objectivity of colour. Many are the groups, suffice it to remember by way of an example: the *Concrete Art Movement* (CAM), which utilizes geometrical forms and flat coats of pure colour, to express "concretely" universal plastic forms that imply the real. The Colour *Field*, characterized by unvaried expanses of colour, which exclude any interest in form or mater. *Minimal Art*, which performs a process of reduction of reality to elementary geometric structures. *Analytical Painting*, which isolates the elements of a painting to renew its language. *Programmed Art*, which aims at fusing the elementary, constitute colour's components with psychology of perception and maths.[2]

In Italy in the Seventies of the Twentieth century *Colour* begins to be considered and taught as an actual subject.

The relevance of an interest in the didactic of colour is testified by the 42nd Venice International Art Biennale (1986), titled *Art and Scien*ce, which dedicates a whole section to the didactic aspect of colour, subdivided by topic: Organized chromatic research.[3] Among others Aldo Schmid and Luigi Senesi, founders of the *Objective Abstraction* group, also exhibit.

THE OBJECTIVE ABSTRACTION GROUP

The *Objective Abstraction* group, takes its name from the *Manifesto* with which the member artists officially present themselves to the public on 17 January 1977, at the "Pergine Valsugana" gallery in Trent (Italy), along with their works. The founders are Aldo Schmid and Luigi Senesi, around whom gather Mauro Cappelletti, Diego Mazzonelli, Gianni Pellegrini and Giuseppe Wenter. The artists present a folder each containing six silkscreen prints (cm. 100X70) in 60 items. The *Manifesto* declares the refusal of symbolism and of aesthetics as an end in itself, toward a global political commitment in which the artist overrides the presence of "I", acts with impersonality and detachment from the subjective impulse, inquiring into colour's scientific and numerical dimension, into its exact mathematical hues and modulations, into its exact quantity of light.

[2] In 1949 Gillo Dorfes, theorist of the *MAC* group, defined Concrete Art thus: "art based merely on making and on the objectivity of the artist's intuitions, rendered in concrete form-colour images, far from any symbolic meaning, from any formal abstraction, and aimed at capturing only those rhythms, those cadences, those chords of which the world of colour is rich".

[3] The Colour*e section* is coordinated by Attilio Marcolli. Among the various subjects treated, Osvaldo Da Pos curates "Psychology of perception of colour and illusions" with tridimensional equipment for experiments on perceptivity, didactic drawings and illustrate charts, while Narciso Silvestrini and Antal Nemcsics curate the theme of "Colour Order Systems".

Aldo Schmid

Aldo Schmid (1935) attends secondary school at the Teacher Training School in Trent (Italy) and art classes at the Sommerakademie Salzburg (Austria). Gradually he abandons figuration to devote himself exclusively to colour: by means of two or more colours he obtains a gradual trans-colouration, fluid and even, generating an iridescent glow within the painting.

In *Untitled* (1973) a cobalt blue circular shape on dark green is traversed by a translucent intersection, at the heart of which a luminous vermilion pulsates giving a tridimensional effect. The colours attract one another by contrast, like the opposites on Itten's circle, creating a dynamic tension whose generative method is initially described by the titles themselves: *From Yellow to Purple*, *Green/blue/yellow*, *Vi/B/AR/ Contrast*, *Gi/AB/V* Contrast. They then turn into abbreviations: *V/BV/Gi* (1975), followed eventually by numerous *Untitled*.

He then creates bichromatic combinations devoid of a visual interval, in which he juxtaposes vertical bipartitures and tripartitures, so that the trans-colourations meet at the centre within the area of colour, forming a sharp and clear cut boundary, where movement converges.

Schmid declares that for him "the synthesis of chromatic opposites is the phase of their annihilation but also the condition of their mutation (…) where tension is a necessary element of the mutation of chromatic opposites which find in synthesis the dynamic moment of their infinite transformation". In *Non* colour (1976), composed by 720 variations obtained from 6 main colours, lithographed on paper and encased within a Plexiglas cube, he shows the most radical aspect of his artistic thinking.

Luigi Senesi

Luigi Senesi (1938 – 1978) studies mural painting and fresco at the Instituto d'Arte in Florence (Italy). After a figurative period he devotes himself to a more structured formal organization, where "colour becomes vibrant screen, sensitive film of the luminous graduation to the limit of saturation".[4] He devotes himself completely to the study of colour, and devises an original method of application in gradual tonal succession: he subdivides the square support into parallel lines in such a way that distances and visual relationships between luminous areas confer maximum luminous and tonal extension to colour. Interested in the Itten's theory of complementary colours, he creates the series of *Chromatic paths*, of *Chromatic Partitions* and of *Chromatic intermediates*, where colours interact with one another by opposition, creating dynamic geometrical forms.

As one can see, the titles of his works speak of his research: *Pulsations*, *Objective subjective transparencies*, *Chromatic margins*, *Post-chromatic*, *Progressions/Contrast*. His theoretical vision is described in some limited edition publications: Colour*: graduation, model, pulsation*; Colour *relationships within the dimensions of the pictorial space*[5] and *Objective subjective transparencies*. *Work notes*.[6]

Itten wrote "We speak of contrast when we perceive evident differences or intervals between two chromatic effects when compared to one another. If these differences are absolute, we speak of contrast of opposites or of contrast of polarities. Large-small, white-black, cold-warm at their maximum degree of opposition are contrasts of polarity." Senesi experiments with the variations of affinity, of transparencies and of interferences, and because of this the critic Licisco Magagnato[7]

[4] Toni Toniato, 1931, artist, poet, historian and art critic.

[5] Arte2000, Milano, 1975.

[6] Edizioni Panda - Galleria L'Alfiere, PD, 1976.

[7] Licisco Magagnato (1921-1987), director of the Verona's Civic Museums, Italy.

has designated him as the “most rigorous in the analysis of possible combinations between colours of the fundamental triad”.

Mauro Cappelletti

Mauro Cappelletti (1948) devotes himself to the analysis of colour and of its application in relation to the format of the canvas, working on the concept of chromatic energy and sequences. He uses a solution of acrylic gesso mixed with polymers in suspension, which vitalize colour, painted in fully saturated coats, because he states: “thought colour is never a shaded colour”. Cappelletti focuses on Itten’s “Contrast of quantity” according to which the determining factors of the effect of a colour are its intensity and dimensions in the colour field. Itten has translated the reciprocal values of luminosity, attributed to colours by Goethe, into numerical proportions:

yellow 3 – orange 4 – red 6 – purple 9 – blue 8 – green 6

And Cappelletti begins with this contrast to develop a sophisticated application of the same, aimed at creating chromatic energy in the compositional relationship between colours, and between these and the format of the work. In *Directional fluorescence*, work composed by three single elements, colours – which for convenience sake we’ll call turquoise and lilac – belong to the same zone of so-called “cold colours” of Itten’s circle, one oriented toward blue and the other toward red are, contained at the extreme left and right by a thin vertical vermilion line, which crosses the central bicoulor panel vertically, separating (or uniting) the two halves.

Diego Mazzonelli

Diego Mazzonelli (1943-2014) pursues a historical and philosophical education and is interested in avant-garde theatre, visual poetry, experimental cinema and painting. Among Itten’s contrasts the light-dark values are present in various instances, at tmes chromatc tones are modulated in nearly identical mid-range luminosity, or, as in the “Contrast of quantity” colours are cut with grey to tone them down. Mazzonelli juxtaposes orthogonal surfaces of fat coats of colour in their darkest declinations, slanting their arrangement in dynamic compositions with luminosity values that fall within a narrow range, and he positons them on a background of absolute black to render them luminous by contrast. As Itten before him, he writes: “Faded hues live of the luminosity of surrounding colours”. Itten had organized the Colour *wheel in twelve parts* to highlight the relationships of complementarity of each colour “based on a concept of harmony and measure”, where equal segments are ordered in such a way that “they occupy irreversible places, following each other according to the order in the rainbow and in the spectrum”. So each diameter in the circumference joins two colours, which Itten considers complementary to each other, organized in gradations that from the highest saturation at the equator dissolve toward the central achromatic axis of greys. In the acrylic series “*Surface-structure-colour*” (1977) Mazzonelli focuses on the complementarity of hues. In the vertical works, contained between two black lines, a single colour is cut in half by a stripe of complementary hue; while those entirely black, are cut in half by a double stripe of colours, always complementary to each other.

Gianni Pellegrini

Gianni Pellegrini (1953) studies at DAMSS in Bologna (Italy), returns to Trento and paints concentrating on the relationship of the constitute elements of colour. His paintings are variations of abstract structures, a play on the interference between line and surface. He spreads colour on the canvas with the brush, layer by layer, veil by veil, allowing the hue underneath and traces of lines, thickened by black colour, to transpire. Pellegrini develops his own version of Itten's "Contrast of quality" between more intense colours and muted colours, obtaining soft and sophisticated surfaces, modulated by shadow-marks, which he allows to evaporate into a hazy, milky luminosity.

Giuseppe Wenter Marini

Giuseppe Wenter Marini (1944-2015) also works on the effect of modulation, juxtaposition and transparency, starting from Itten's "Contrast of quality", which he calls *Space with progressive chromatic transparencies*. He participates to the foundation of the group, but he abandons it soon after, moving to Brussels (Belgium).

CONCLUSIONS

The sudden death by railway accident of the two leading artists, Aldo Schmid and Luigi Senesi, marks the premature end of the communal experience.

To conclude I remind the reader of how Itten's formulations are influenced by his support of Mazdeism – according to which the whole universe is based on duality, opposition, difference - and of his attendance of the theosophy circle of Alma Mahler, Walter Gropius' wife. Gropius then called him to join the Bauhaus.

As a matter of fact, Itten writes: "A word and its sound, form and its colour are manifestations of an afterlife which it is given to us to foresee, through watching and listening. (…) The primordial essence of colour is a dream-like harmony, it is music turned into light. (…) The meaning and purpose of each artistic endeavor is to free the spiritual essence of forms and colours. (…) A painting today has its own motivation in and of itself, within its colours and within its forms".

It is interesting to observe how from his teachings, so steeped in mysticism, came the a-religious research of the "*Astrazione Oggettiva*" group, whose pictorial and philosophical assumptions have been the search for an exact and objective aesthetic perfection (called "organized chromatic research" in their Manifesto), which totally rescinds from nature in name of rationality and abstraction.

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colour & human comfort

Painting in Lab: Sensory Experience on Primary Blue

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ABSTRACT

Lab Colour Sense project, related to the Ph.D., aims to summarize and discusses the process that occurs in human perception: sensory impressions, organizing process, and the interpretative process of Visual Perception and Dermo-Optical Perception (DOP). The participants of the 5th Encounter on Practices of Research in Art and Education were invited to analyze their cognitive process during the contact with "primary blue" colour with the intent to investigate the dialogues between body and colour during the practice of painting, through self-experience and self-analysis. This research workshop attempts to abstract oneself from their own experience, wherein the methodological process is to investigate how participants create their methods which led their actions/experiences with colour. The writings of the participants are very critical to see what 'colour thoughts' might be in the insights of them in attempts to understand something more of the substance and nature of colour.

Keywords: Painting, colour, human body, cognitive education, self-reflection.

INTRODUCTION

This research project of an ongoing Ph.D. research in Artistic Education that I am calling 'Lab Colour Sense', is being conducted in an academic context. This study focuses on the interaction between the physiological and cognitive processes that origin the determination of emotions. With such a framework, applied to colour, the participants were asked in this workshop to deal with colour and appreciate different cognitive processes, with the intent to understand perception as an active process of creating meaning by selecting, organizing and interpreting emotions.

Working as an artist and as a researcher in both, painting and artistic education, the research attitude towards this study comes down only as a mediator and researcher in action of this dialogic process of interaction with perception, concepts, and materials. In this process, the methodology, as an individual creation, is not replaceable or teachable. Instead, it consists of procedures that generate a methodology. This fact is well exploited by Weber and Mitchell (1999), and quoted by Hernández (2008, pp. 85-118). This workshop is a path necessary for building and articulation of our cognition relational procedures with colour during the act of painting. The analysis of the reflexive process and artistic expression reveals private self-aspects and puts us in full connection with our emotions. That is a multisensory response that gives rise to learning at the level of the senses. In this direction, questioning the accuracy required to scientific investigations when applied to education, it is possible to consider that principles and procedures of artistic activity may transform educational practices.

PERCEPTION

In the 19th century, perception was studied as a passive stamping done by outside stimuli on the retina. It would then reach the visual cortex, the zone of the occipital cortex that receives stimuli generated in the retina, resulting in an identical image (isomorphic) as the primary stimulus. Modern psychology refutes this notion and views perception as an active process that involves the search for corresponding information, the differentiation of essential aspects of an image, the comparison of these aspects with each other, the formulation of appropriate hypotheses and the comparison of these hypotheses with the original data (Bruner, 1957). Telford (1970) differentiated sensation from perception in that the first comprises a pure conscience of the dimensions of experience, while perception implies the sensation and the meanings that are attributed to the experience. Theories about perception tend to emphasize the role of either sensory data or knowledge in the process. Some theorists have adopted a data-driven or bottom-up stance, or synthetic approach, according to which perception is direct: visual data was immediately structured in the optical array before any selectivity on the part of the perceiver proposed by Hering (1964), Gestalt theories, and Gibson (1979). Others adopt a constructivist, top-down or analytical approach emphasizing the importance of prior knowledge and hypotheses, defended by Berkeley (1709), Helmholtz (1925), and Bruce, Green and Georgeson (2003). The human brain has been studied in many details, and one way of organizing the study of different functions of the brain was to divide it in areas.

Processes of Primitive Vision considered bottom-up by neuroscientists, which are processes that do not require previous knowledge and are not determined by learning or experience, are the perceptions of movement, depth, form and colour vision. Findings in neuroscience have mapped the visual pathways (Zeki, 2000) and have determined that perception occurs through a neural cascade, activating areas of the brain that are often very far apart. Perception does not occur through isolated processes in the brain; our eyes perceive only a limited part of the electromagnetic spectrum which, in daylight, reveals to us the colours and shapes of our environment. The skin is sensitive to a broader range of this spectrum, as shown by tanning due to the ultraviolet radiation of the solar spectrum or the sensation of the accompanying heat due to infrared radiation. However, even if invisible, this radiation surrounds us entirely, and it would be surprising if it did not influence our actions. Electroencephalographic recordings have proved that DOP is not located in the vision center of the cortex in the rear part of the brain, but in the centers of tactile and thermal sensation. They also showed that every subject had the same electroencephalographic results, which confirms that DOP is inherent to every human being (Campbell, 1998).

It should be pointed out that the word "dermal" does not mean tactile in the sense of directly touching a surface, as the coloured surface can cause reactions even if it is under a transparent or opaque screen and the subject is a certain distance from it. It is indeed necessary to distinguish unconscious dermo-optical effects from their conscious perception by differential, but not perfect, subjective impressions.

EXPERIMENTAL

The processes of interaction/observation/recording of the phenomenological analysis of perception related to colour in this painting practice context were recorded with no other ambition than to describe these process as accurately as possible, based on both the participant's linguistic analysis and their descriptive texts. All sessions were photograph and video recorded. This action research workshop attempts to abstract oneself from their experience, wherein the methodological process was to investigate how participants create their methodology which led their actions/experiences with colour. This process gets us to a multisensory response that gives rise to learning at the level of the senses.

Subjective impressions between Visual Perception and DOP

The first phase implied technical evaluations using instruments and objective parameters, to access the emotions and cognitive symptoms of the participants during painting practice. This analysis was mainly based on observation of the dynamic between participants and colour performance, through the following instruments:

- Offset paper (50x70cm), tempera ink on "primary blue" colour, brushes.
- Questionnaire.
- Video and photo cameras.

This case was aimed at collecting reports about the cognitive perception of the participants during painting practice and after. In particular, the study was comprising:

- *A* colour *based survey*: an experimental visual stimulation where seven participants (10% male and 90% woman) were asked questions about visual and DOP, the last one under indirect observation.
- *A multimedia-based survey*: an experimental survey based on videos and photographs.

The results of the experiment were analyzed and used to gather:

- To understand the correlation between expression emotions and cognitive symptoms in each colour.
- Dermo-optical subjective impressions; participants were invited to participate in this experience to investigate DOP in contrast with the Visual Perception; they were asked to close their eyes during five minutes in this experience.
- Critical insights based on the social experience of colour perception during painting practice for optimizing and improving other ways of feeling and seeing colour.

Figure 1: Visual Perception on painting practice experience.

Figure 2: EPRAE participants in the classroom during the DOP in “Primary Blue” experience.

RESULTS

Despite colour’s basis in wavelength, the apparent norms of developing colour terms in language development, and the physiology of the human eye, cultures do interpret and use colour in different and distinctive ways. The ability to discriminate some colours is hugely variable, and the interpretation and linkages between objects and their colour are multifarious. The writings of the participants are very critical to see what ‘colour thoughts’ might be in the insights of them in attempts to understand something more of the substance and nature of colour. The most important for them was examine that painting practice with a particular focus on colour, can add to self-knowledge.

Some examples of how participants defined the "primary blue" colour in the Visual Perception and DOP experience as:

Participant A:

- Visual Perception: *"*Colour *we find in various elements of "nature" and other unnatural elements; Associated with calm; Cold* colour*; Emits electricity/light; It is summer* colour *in the Mediterranean countries; It was the* colour *of the official stamps ..."* (Fig. 1).
- DOP:*" After five minutes, with eyes closed, trying to perceive the* colour *blue through dermo-optic perception, initially felt warmth in the hand on the white surface and cold on the blue; At this stage the blue* colour *was present in my head; After some time, the cold-heat sensations changed: the hand "over" the blue heated and the hand over the white cooled; In this second phase (within five minutes) my thoughts wandered through a multitude of pending issues that had nothing to do with the situation, but one of the subjects was related to the sea ...".* (Fig. 2).

Participant B:

- Visual Perception: "*Formal* colour*, cold in contrast to red, refers me to space, infinite, infinite opaque or transparent, is great for reaching the green of nature, but only when the yellow (pigment* colour*) is added."* (Fig. 1).
- DOP: *"The sensation was to feel warmth in the palm of the hand, which produced a pleasant sensation. I could not help but think it was the* colour *blue and it should be cold, but it felt like heat. Perhaps the relation to the* colour *blue, when we say: "the* colour *blue is cold" is a myth, fruit of our education. In fact* colour *can create sensations. I could only feel and think about the temperature and wondered about it."* (Fig. 2).

Participant C:

- Visual Perception: Freedom, heaven, peace, enlightenment, birds, peaceful sensation." (Fig. 1).
- DOP: "*I felt that the blue* colour *emitted a source of cooler air, the right hand in the white* colour *remained stable. However, the blue* colour *in the left hand, made me feel that there was something cold, a sensation of cold, a sensation of cold in hand. Feeling of peace and tranquility."* (Fig. 2).

CONCLUSION

There is a collision of understanding about, with knowledge of the workings of light waves sitting uncomfortably alongside the perception of colour by variable physiologies, and the propensity to interpret colour concerning external objects and emotions. The exploration will be of whether this is a challenge or unsolvable debate, or a space of creative engagement in which both sides can benefit and which provides a basis for intrigue and fascination which might lead to a reconciliation of the subjective and objective positions that have traditionally characterized the approaches to art and science. I aim to search the range of interests within current academic and practitioner activity in the colour arena of the visual arts and to draw interested colleagues together to initiate future projects to explore the field more systematically.

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Colour Free, Colourlessness

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ABSTRACT

The *white experience* comprises an impressive variety of experiences that touch human mind-body-soul in different ways. From the experience of nature to the creation and experience of art, from description of phenomena to abstraction and reflection, the white colour is particularly significant to human life.

The white discourse on Aalto's oeuvre is already found in a comprehensive way in Aino Marsio and Alvar Aalto's earlier works such as the Viipuri Library (1927-1935), the Paimio Sanatorium (1929-1932), or the Villa Tammekann (1932-1933). Their discourse on the white colour, on the crafted natural materials and on the technology as a heritage from constructivism is going to be present throughout Aalto's oeuvre.

"The Humanizing of Architecture", published in 1940, made clear that the discourse on Viipuri was already something very deep where architecture mingles human life and thus white, light, space-time and the materiality of architecture challenge the human soul.

Keywords: *Aalto, Library, Mount Angel, white, colour*

INTRODUCTION

On the 30th of May 1979, in the New York Times, Ada Louise Huxtable expresses her views on Aalto's Mount Angel Abbey Library according to the following words, "The Aalto palette of white walls, black seating, and pale, warm woods, a beauty intensified by natural light from high windows and skylights and warmed by a carefully supplementary incandescent glow, proves again that no colour can be the richest colour."

In what might be called a surprising narrative of the architectural discourse, Ada Huxtable illustrates a full colour environment despite the fact that the conclusion goes to a somehow colour free architectural environment. This type of speech may arise from the difficulty of describing an actual architectural discourse and also from the great difficulty that such discourse exposes in describing colour as a fundamental environmental phenomenon.

The reference to “warm woods” certainly embodies what is widely accepted as Aalto’s signature and, in a *lato sensu*, to Scandinavian architecture. But it creates a displacement within the wholeness of the architectural environment where the artificial and the natural oppose each other and yet can be combined. In this particular discourse it is somehow suggested that the perfect fulfilment of architecture with colour must be the access to the natural colour of nature.

However, the perfect colour of nature can be challenged. Gauguin’s selective methodology regarding the reading of environment concerning colour, created along with other painters such as Van Gogh, or the Impressionists *versus* the Expressionists proper ground for a sense of metamorphosis from the natural to the *un*-natural. Thus, former concepts of form such as the contour of the object, a Renaissance concept, give place to more complex evaluation of the world we live in. The world we have to transform to live in, in order to create our own culture. Surface versus impression needs a characterization to each contour that is blind and is where colour-texture lives a unique life. And architecture despite of being able to be defined by the contour of geometry is full of surfaces and inherent colours. From the ground we step on, to the shelter with ceiling and wall and openings that define space, colour-texture became parts of the tectonic evaluation of the built object.

But the search for the natural colour as a perfect match to architecture may need some further evaluation. In 2005, Dominique Perrault states that “Il n’y a aucune relation entre le naturel et lártificiel. Cela n’existe pas. La nature est un materiau parce que c’est un matériau. On peut la manipuler ; partant, elle devient artificielle. […] la nature dans son acception du XVIIIe s. n’existe plus.” And thus, colour may struggle for her own survival as an autonomous thing that cannot exist alone because it must be confined to some type of materiality as an actual architectural thing.

EXPERIENCE OF NATURE AND THE EPISTEMOLOGY OF COLOUR AND ART

Experiencing a landscape tells much about what Maurice Merleau-Ponty refers to the perception of colour. Colour is not an abstract thing, it is always the colour of something whose materiality opens the way to the eidetic reduction admitted by Edmund Husserl. Thus, nature sets on in us, not only colours but colours that fall into some kind of organization which is material and intrinsic to the materiality of the world we fashion.

Acquaintance with a colourful nature may then proceed to some kind of “consensus” that is the territory of epistemology. Yet the frontier between the qualitative and the quantitative might not be easily reached and a compromise between the qualitative and the quantitative might be a particularly useful tool to explore colour. It might not be possible to make everything *black-and-white* clear, but, perhaps *black-and-white* are good to be further explored.

From Munsell to NCS, black and white seem to be the “easiest” colours to place within a secure *geometrico-mathematical* framework, a stable place in an arrangement of colours. In this context it is extremely interesting that Malevich found in *black-and-white* the heuristic exploration by which painting could set its own way apart from mimesis. Yet, there is another important phenomenon that comes into art which is the problem of art as a product as a mental process that must not have any boundaries otherwise we admit from its outset some limitation to human understanding and creativity. Thus, both abstract and figurative reference have reached new paradigms.

At the core of the phenomenology, the approach to us and to the world we live in means that the phenomenon of the mental processes radicates from the process of *self-awareness* that makes consciousness a true human phenomenon regarding its constitution in the *body-mind-world* environment. That is, regarding Husserl, there must be an eidetic reduction *in-us-to-us-to-the-world-to-us* otherwise any further eidetic reductions would be impossible. Perhaps, somewhere there, we may find some grounds to explore Aalto's whiteness.

AALTO AND MALEVICH IN BLACK-AND-WHITE & THE WHITE TABLE

Aalto's discourse on *black-and-white* opposes that of Malevich. Would that be the reason why Ada Louise Huxtable found in Aalto's white a strong working environmental resource, a colour-free environment where everything begins?

Malevich's *Black-on-White* square is the rupture with mimesis. It is the statement of an art that can have its own means to stand forward away from nature and any figurative references. That art is self-sufficient and free of any addressee. There is not a compromise between the artist and the public.

Yet, on the contrary, we easily find in Aalto's oeuvre and writings many clues that his *black-and-white* are the splendor of the affinity with nature. There is the intention of humanizing architecture, the most basic compromise that the architect must not forget, that is, the destiny of architecture, the human life. This is perhaps the reason why Aalto's use of white works as an effective colour in an equivalent way to Gaugin's use of strong colours or to the strategies used by the expressionists regarding the invention of a world of colours.

"The white table" is one of the iconic passages that Göran Schild, the famous Aalto's biographer as offered us. The idea of *table-and-white* being a single object and a territory to imagination where everything begins and can be created is particularly important. A sensible object to children and to adults, to professionals, an object that garters generations and deeply embodies art production. And later Göran Schild stresses the role of painting in Aalto's earlier years, painting that owes much to expressionist methods of expression. Yet, we may also find a way to shortly explore Finnish painting, specially Akseli Gallen-Kallela (1865–1931) as a symbol of Finnish spirituality.

AKSELI GALLEN-KALLELA, FOREST, WHITE AND THE KALEVALA

Akseli Gallen-Kallela, the forest and the Kalevala meet deeply at the core of Finnish spirituality. It is a problem of culture and civilization that was brought to life under Gallen-Kallela's brush at a time when Aino Marsio and Alvar Aalto were brought from being children of the forest to full artists, designers and architects.

We may find the white colour on paintings such as Camille Pissarro's *Rabbit Warren at Pontoise, Snow* (1879), on Mary Cassatt's *The Child's Bath (1893), or* on Paul Gauguin's *Visions After the Sermon: Jacob Wrestling with the Angel* (1888), but Akseli Gallen-Kallela works on the white colour a strategy that those painters did not use regarding the white.

The white colour is dramatically crucial to the aesthetic power of Gallen-Kallela's Kalevala thematic based paintings, those paintings that touch deeply Finnish spirituality. "Lemminkäinen's Mother" (1897) is one of the works that that masters this technique. "Joukahainen's Revenge" (1897) is another one. Here, the white composition is strategic and informs strongly about the character of the landscape and of people. White is mass, it is actual living matter where human drama proceeds on his own way. The white is tragedy in these two paintings. It is active but is not the idyllic nature of the romantics to be fashioned. Thus, the white is deeply embodied with human life.

The two former art works use tempera, but the white is not confined to this technique. “Kullervo Cursing” (1899) masters oil on canvas. The white finds an exquisite acme of intensity and drama at the eyes of Kullervo. Precision. A full architecture of *white-whites* combined to link the nature of forest and the nature of human kind.

Would, then, be such an intensity that Ada Louise Huxtable finds in Mount Angel and yet not directed to the experience of drama, but to the exploration of culture and spirituality in which the place of books is a place to find *oneself-and-the-other*, to find the nature and spirituality of Mount Angel from its strategic placement in the landscape?

THE STOA – *ΣΤΟΆ* – THE AMPHITEATRE AND THE LIBRARY

In May 1983, Architecture and Urbanism released an Extra Edition on Alvar Aalto in which we find a typological exploration of Aalto’s fun shapes. Seinäjoki (1965), Rovaniemi (1968) and Mount Angel (1970) are found all together along the same line of development. In fact, the fan shape became one of Aalto’s iconic motifs and, curiously, the most difficult classical shape to be challenged at the trial of the free plan.

The right angle-based form became easily challengeable after Le Corbusier (1887-1965) created his pillar-slab structure to the *Dom-Ino House* and his famous Five Points for a New Architecture opened the way to a new free order of architecture nonetheless submitted to a basic order as a guarantee of freedom. These ideas would be enriched by Gerrit Rietveld (1888-1964) spatial flexibility materialized in the Schröder House (1924).

Yet, the fan shape remains as an impressive challenge to the free plan and to the flexibility of space. The articulation between the *Odeon of Herodes Atticus* and the *Στοά* of Eumenes on the acropolis of Athens are the distinct mark of the dialectic exploration of Aalto’s fan shape, perhaps the motif that mostly represents his work. The curved shape of Greek theaters could articulate a strong sense of geometry worked in a superimposition to the land whose topography was nonetheless manipulated regarding a continuity natural-artificial.

The shape of Aalto’s libraries in Seinäjoki, Rovaniemi and Mount Angel discuss an opposition, but also a continuity, between the right angled-based organization of space and the curved fan shape. Somehow, the aim of the special organization is always to take people to an acme of the aesthetic experience to take place in a dynamic way under the involving fan shape. According to the pursuit of this objective, the fan shape needed to undergo through an important metamorphosis that would recreate the centrifugal versus the centripetal forces. This process would create a sense of free flexible plan beyond the classical conception where the public attention was addressed to a center.

Thus, Aalto proceeds into some kind of free transformation of the fan shape and would create *spaces-in-space* with different heights and following precise distributions that would relate the different floor levels to the ceiling which then would be a territory to explore shapes and light, either artificial or natural. In fact, such process was introduced in Viipuri, but what might be seen related to fan shape alone would be the main stairway from the vestibule up the core of the library. Yet, other processes of articulating different heights of space, of creating different spatial sensory places, are already there. And the process of creating free forms related to some rational rule is also found in the ceiling of the conference room.

The fascination of ceiling and sky is classical and also relates to the exploration of landscape. The cosmos and the heavens are fascination. From the Roman Pantheon, in Rome, to Aalto's libraries there is a comprehensive history of exploration of light and space. Much of Aalto's strategies could be understood from different explorations of the classical as well as their combination with the Finnish white nature where, sometimes, a continuity of *white-whites* embodies the land, the horizon and the sky.

Seinäjoki-Rovaniemi are developed on a flat land, but Mount Angel articulates a plateau, a slope, a wide spread landscape, a different kind of territory. And this is the main difference between the Mount Angel and the other two libraries. But this means that, generically, in Seinäjoki-Rovaniemi we get in through an architectural right angled-based promenade that narrows when we get in and opens powerfully to the upper light and space when we are already experiencing the fan shape. Rovaniemi offers two directions, one of them offers a colonnade along the building an in the other the same colonnade becomes a front portico.

Yet, in Mount Angel, the effect is to enter the fan shape from the upper level and proceed to the lower levels that follow the topography of land and thus the level of the light-ceiling becomes strongly powerful in a different way. The void is active through the mezzanine. The curved shapes of the ceiling explore white-grey scales, or as one can emphasise, explore many white-whites, and this is particularly important in the spatial sense of spaces. Thus, geometry, and the variety of the white colour, which is changeable when we walk through, is constructed together with black seating and warm woods. In many senses, there is a metamorphosis of the Finnish natural environment into architectural strategies that must be selective in terms of aesthetic values.

WHITE, BLACK-AND-WHITE CONCLUSION!

Architecture is artificial and thus, from its outset, we must be aware of a sense of artificiality, that one that Dominique Perrault tells about in a radical way. But we should also reflect if that radicalism does make clear what mental processes have been developed when nature and architecture have been embraced together.

Nothing is more artificial than a white plastered wall and thus there is another phenomenon which is the cultural discourse that deals with aesthetic values and this is what combines Akseli Gallen-Kallela with Alvar Aalto. There is acquaintance with nature and art and there in precision in producing a new architectural discourse afresh.

Malevich discourse on *black-and-white* did not target the humanizing of the art work in the way that architecture should act, but it elucidates the importance of mental processes and conceptualization of art. In this sense, it is a highly precise statement such as that one we experience in Kullervo's eyes and therefore it is not alien to humanization of art. Thus, the roots of Aalto's *white-work* may yet to be found.

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What Colour is the Dove's Plumage? A Study of the Colour Adjective *yraqraq,* in Ps 68.14

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ABSTRACT

Psalm 68 is well known for the difficulties of interpretation it presents. As YHWH addresses his people using the image of a dove, the poet describes its wings and plumage through a beautiful parallelism and a recurrent literary motif: that of *silver-gold*. However, unlike silver, the gold here is described with the adjectival lexeme *yraqraq*, suggesting a hue which has been much discussed both among exegetes and in modern versions of the Bible. Today, the field of cognitive linguistics provides us with a theoretical framework and a series of useful lexicographical tools for this study, including the need for an encyclopaedic knowledge that will situate us in the world of speaker. From this, we can deepen our knowledge of the psalm's context and the referents of the colour term: *dove* and *gold*. We have concluded that the dove's plumage is imbued with a greenish gold colour.

Keywords: *colour term, cognitive linguistics, bible, hue, green*

INTRODUCTION

It is enough to open one's sleepy eyes on some summer morning to contemplate, perhaps unconsciously, the array of colours that give life to the reality the darkness has kept hidden. This visual perception has been going on as long as man has existed. However, what has varied over time is the way in which these colours are named, and the concept of colour itself. Since antiquity, the poet has with his calamus tried to capture in words what he feels and to infuse what he sees with colour. This is the case of the psalmist of Psalm 68. He sings joyously of the triumph of the chosen people, comparing it to a dove whose wings are like silver and whose feathers are like gold (Ps 68.14). This use of colour, however, is not limited to the classic literary motif of *silver-gold*, but adds a personal touch by describing gold with an adjectival lexeme that denotes colour: *yraqraq.*

The question that arises is how to approach today the chromatic nuance denoted by *yraqraq,* when our own concept of colour is so different from that held in antiquity, and when many chromatic terms in Hebrew appear to us as being polysemous. As will be shown here, the field of cognitive linguistics provides us with just such a theoretical framework for the lexicographical study of these terms and the tools needed to unlock their meaning.

THEORY

Cognitive linguistics (CL) is an interdisciplinary discipline that considers language to be a faculty related to other cognitive faculties. According to CL, language is not autonomous, as it is related to the thinking and bodily experience of the individual. The study of language thus becomes focused on usage. Its essence is meaning is and, to gain access to this, it is necessary to know the world of the speaker (Ibarretxe, 2010).

Following this hermeneutic framework, accessing the meaning of *yraqraq,* obliges us to start from a definition of colour that will serve as a connective link between the concept of colour that existed in antiquity and ours today, as well as to deepen our knowledge of the speaker's world. This aspect is vitally important to the study of colour, as colour adjectives are used to describe concrete entities. In some cases, a detailed study of the entity described enables us to determine the tonality reflected by the adjective.

We are following here the definition of colour proposed by John Lyons (1999): 'colour is the property of physical entities and substances which is describable in terms of hue, luminosity (or brightness) and saturation and which makes it possible for human beings to differentiate between otherwise perceptually identical entities and substances, and more especially between entities and substances that are perceptually identical in respect of size, shape and texture'. Our motives for adopting this definition are three: a) it respects the concept of colour that was held in antiquity (a quality of physical substances; that which is visible); b) it allows us to consider that the chromatic lexicon of antiquity expresses, above all, luminosity; c) it synthesises the characteristics of our current concept of colour: tone, luminosity and saturation.

As for knowing the world of the speaker, the modern scholar is forced to pose a series of questions, the answers to which will gradually situate him within the universe of the text. To do this, a variety of scientific disciplines come into play –linguistics, literature, archaeology, biology, botany, history, etc.– and these provide the encyclopaedic perspective from which the meaning will emerge.

RESULTS AND DISCUSSION

As mentioned before, Ps 68.14 poetically describes the people of Israel as a dove with wings of silver and feathers of gold. The peculiarity of the pericope lies in the poet's description of gold with the adjectival lexeme *yraqraq*. This lexeme is considered to be a colour term which, combined with a greenish tonality (BDB; Bulakh, 204), denotes a number of chromatic variations that reflect luminosity or lack of saturation (Brenner, 124), such as pale green (BDB), yellowish green (HALOT) or yellow (Hartley, 135; Bulakh, 204). This explains the fact that modern translations oscillate between highlighting either the hue of gold –*yellow* (ASV; KJV; NKJV) or *green* (NRSV)– or the quality of luminosity: *bright* or *shining* (NIV). At first glance, the meaning of *yraqraq* may correspond to any of the proposed translations, as gold is usually yellow (for which it is the classic epithet), or greenish (when mixed with silver or bronze), or has a particular brightness that can be emphasised by the use of *yraqraq.*

This same diversity can already be seen in early translations of the Bible:

– LXX interprets the adjective *yraqraq,* as having a nominal function and *charuts*, by contrast, an adjectival one. Χλωρότητι χρυσίου is thus translated as *golden greenness* (NETS).
– The Vulgate presents two different interpretations, as it is well known that Jerome did two translations of the Psalter: the *Psalterium iuxta Hebraeos,* following the principle of *veritas hebraica*; and the Gregorian Psalter, which is the translation of the Greek version. In the *Psalterium iuxta Hebraeos*, *yraqraq* is translated as *viror (green colour, greenness*), while in the Gallican Psalter (*pale colour, paleness*) is used for χλωρότης.
– The Targum of Psalms omits the chromatic description of the adjective *yraqraq* and resorts here to a gloss: *pure gold*.

Given that the expression *yraqraq charuts* describes the wings of the dove, it is fitting to wonder whether the poet is thinking of a real or a figurative dove, as when this referent is identified we can better understand the tonality expressed by the adjectival lexeme. For the first case, two hypotheses have been proposed:

According to John Hartley (2010), the poet is thinking of the liberation of doves during a victory celebration. On their ascent toward heaven, their feathers would take on a yellowish tone as they reflected the sun. This proposal is supported by two archaeological artefacts: 1) the ivory plaque of Megiddo, which shows the king receiving the spoils of war while birds similar to doves are seen flying around him; 2) representations of doves in Egyptian palaces, a custom which may have spread to the Israelite world.

On the other hand, *Easton's Bible Dictionary* indicates that there is in fact a species of dove in Damascus whose characteristic colour is yellow, with the exception of its wings. Lourdes García Ureña (2016) has suggested that this could be *Treron phoenicoptera*, whose colouring is predominated by shades of grey, yellow (bright yellow, mustard) and greenish:

Figure 1: *Treron phoenicoptera.*

As for the figurative dove, a military trophy in the form of a dove has been proposed (Oesterley, 1962; Lipiński, 1973; Gray, 1977). In this case, however, there is no unanimous interpretation of *yraqraq*. Some are inclined to read this as a greenish colour, as this is the tonality presented by the paleness of gold and bronze damascene work, such as that found in the excavation at Min*et al*-Beida, or of silver-plated gold, while others propose the yellowish tone or the brightness characteristic of gold in general.

These proposals, however, are still only hypotheses. No military ornamentation or insignia in the form of a dove has been found whose dating is consistent with the psalm's composition, nor is it certain that the term refers to a real dove. Consequently, the dove reference does not serve to clarify the tonality of *yraqraq*.

It is necessary, then, to analyse in detail the entity described by the adjectival lexeme *yraqraq*:

charuts, gold. Gold was considered a precious metal from the earliest times (Gen 2.11), even though it is rarely found in archaeological sites. It is mentioned frequently in the Bible, as it was used for priestly vestments, cult objects, jewellery, decoration, temple construction and commerce. It came from Arabia, Sheba and Ophir (1 Kings 9.28; 10.1; Job 28.16), but not from Palestine. Its natural characteristics (brightness, form and quality) and its various types were well known (*Easton's Bible Dictionary*). Indeed, the Bible, along with *charutz*, uses different terms to refer to gold (*zahab*, *yellow gold,* Exod 25.11; *kethem, pure gold,* Job 28.19; *paz, refined gold,* Ps 19.11; Prov 8.19) and even nuances these types through the use of nouns (*sagur zahab, pure gold,* 1 Kings 6.20) or adjectives (*zahab tahor, pure gold,* 2 Chron 3.4; *zahab towb, fine gold*, 2 Chron 3.8. From this intertextual perspective, the adjectival lexeme *yraqraq* would describe a specific type of gold. Moreover, it is not first time in the Masoretic Text that the literary motif *silver-gold* is enhanced by an adjective to describe gold. Thus, for example, in Prov 8.10 it is said that gold was *nivchar, chosen.*

What type of gold, then, is described by *yraqraq*? Considering the triumphal context in which it appears, the poet seems to be referring to a gold which was extremely precious. Its quality is emphasised not only by the presence of the lexeme *yraqraq,* but also through syntax. The poet places the preposition *be* together with the adjective *yraqraq,* rather than with the noun *charuts,* as he had done in an earlier verse with silver. Some scholars have proposed that the outstanding characteristic of this type of gold is its brilliance (Hartley, 2010); however, this interpretation is not convincing, as in the biblical world it was well known that precious metals have similar characteristics and that brilliance is a quality of both gold and silver. It seems, rather, that *yraqraq* does not describe luminosity, but some tonality of gold that gives it an added value, that accentuates this value and that was familiar to the community that recited the psalm. For this reason, of the yellowish or greenish tonalities suggested for *yraqraq,* the first of these may be dismissed as it merely adds a redundant value to gold which does not concord with the emphasis that the poet confers to the pericope. On the other hand, a greenish hue would accentuate a type of gold that departs from the standard variety that was characterised by a golden or yellowish colour. This proposal is supported by the commentary to Ps 68.14 composed by one of the leading medieval exegetes, Dunaš ben Labrat (c. X):

"*yraqraq charuts* is the gold which comes from the country of Hawilah and the country of Kuš: an extraordinarily fine gold, which is neither green nor red, and this is why they called it *yraqraq*, 'greenish', just as 'reddish' white *ʾadamdam*, is neither red nor white. This explains the reduplication found in *yraqraq* and *ʾadamdam*. And we know that *yraqraq charuts* does not take on the aspect of red gold until silver is added in the forging process".

This same chromatic description of gold is also found, centuries earlier, in Latin literature (The Etymologies of Isidore, 16. 7. 16).

Therefore, it may be concluded that *yraqraq* denotes the greenish tone of a variety of very precious gold. This would account for the gloss of the Targum and the interpretive variants found in the LXX and the Vulgate.

CONCLUSION

Following CL guidelines, and after establishing a definition of colour that may serve as a bridge between the concept of colour that existed in antiquity and that of today, we have acquired the necessary encyclopaedic knowledge of the lexeme *yraqraq*, having studied the available lexicographical sources, the poetic context in which it appears, the various types of dove that the poet may be referring to, the characteristics of gold and its use as a literary motif in the Bible. In the light of this study, we propose that the feathers of the dove have a *greenish gold* colour. This is moreover a fitting hue for both types of dove under consideration, as well as for the war trophy and for *Treron phoenicoptera.*

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colour & human comfort

Cooking as an experiential method in colour education

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ABSTRACT
This article presents a project carried out with students enrolled at the Escuela Superior de Diseño de Madrid during the 2016-17 academic year. Adopted as a point of reference for realising this educational experience is a reading of the chapter titled "The Case of the Colour-Blind Painter" from the book *An Anthropologist on Mars* (Oliver Sacks, 1995)[15]. The main character in this article suffers from achromatopsia, also known as total colour blindness. The aim of this project is to show design students the possibilities of formalising an idea based on the concept of *non-colour*. For this purpose, students are asked to design an achromatic gastronomic experience. The results of this initiative reveal a wide variety of creative solutions. The project serves, on the one hand, to validate cooking as yet another medium for bringing us closer to the experience of design and colour. And, on the other, it demonstrates how chromatic limitations boost formal and conceptual creativity in design processes.

Keywords: *colour, cooking, education, design, achromatopsia*

INTRODUCTION

The participants in this project are future design professionals who are taking the *Colour* course, an artistic component of their university programme in design. *Colour* is a mandatory basic subject for first-year students and is applicable to the specialisations dedicated to graphic, interior, fashion and product design. This is a theoretical-practical module taught over the course of just one semester.

The project is part of the theoretical content of colour perception, eye physiology and injuries of the mechanisms involved in transmitting information from the eye to the brain. This programme seeks to create a suitable iconic framework for a user experience with specific

[15] Sacks, O. Un antropólogo en Marte. Barcelona, Anagrama, 1995.

instructions: design based on the *non-colour* concept and the use of cooking ingredients as the means for the chromatic mix.

ARTISTS AND CHEFS: A COMMON LANGUAGE?

The language of colour, the value of the natural colour of foods and the possible chromatic variations are ingredients that are brought to light in both the works of artists Sophie Calle and Antoni Miralda and in the results of elaborate Mediterranean haute cuisine dishes prepared by Jordi Roca, Andoni Luis Aduriz and Rodrigo de la Calle.

Sophie Calle proposes *The Chromatic Diet* (1997), where each day of the week, Maria, a fictional character, eats foods with a previously established colour (Auster, 1997). In his installation entitled *Breadline* (1977), Antoni Miralda transforms the natural colour of bread into edible doughs of saturated colours. Miralda builds a wall using red, green, yellow and blue loaves of bread, alluding to America's Great Depression.

At the same time, chefs use the terms characteristic of the language of colour in defining their dishes. Chef Andoni Luis Aduriz of the Mugaritz restaurant presents *Edible Rocks*, a culinary trompe-l'oeil. Aduriz employs this artistic term to explain how to obtain an edible colour of grey that imitates the colour of river rocks. In the *International Journal of Gastronomy and Food Science,* Aduriz and Lasa list the ingredients needed and the recipes used to obtain different intensities of greys (Aduriz, Vergara, Lasa, Oliva, & Perisé, 2012).

Pastry chef Jordi Roca is creating a line of desserts called *Chromatisms*. The ingredients used in the *Green Chromatism* creation (eucalyptus leaves, avocado, limes, etc.) and their manipulation contribute to attain a generous green monotonal scale. Chef Rodrigo de la Calle makes his *Blue Cuisine* presentation at the Madrid Fusión, Tasting Spain convention (Madrid 2018). During his conference, the chef demonstrates his gastronomic creations using phycocyanin, an edible vegetable-based pigment that is blue in colour. *Bloody Mary with Celery, Diamonds of Blue Villaconejos Melons, Lettuce and Asparagus Salad with a Hint of Tomato à la Phycocyanin* are the names of the gastronomic creations in which Rodrigo de la Calle alludes to the new chromatic value applied to his dishes.

THE *NON-COLOUR* OF CULINARY INGREDIENTS AS AN EXPERIENTIAL PROJECT

The methodology of this project is developed throughout different semesters of the same academic year with two groups of 18-20 students. Students are split up into four groups of five students for the first semester and they work in teams. For the second semester, the activity is carried out individually. The educational gastronomic activity is conducted over four sessions.

First session. Project Presentation.

As the starting point for the activity, students are asked to read the chapter called "The Case of the Colour-Blind Painter" (Oliver Sacks, 1995). The author narrates the problems involving the visual perception impairments endured by a painter following a traffic accident. On the one hand, he sees reality in a grey scale and, on the other, intense daylight is overwhelming for him. As a result of this, he encounters tremendous difficulty when painting, cannot tolerate being in places with full sun exposure, and he is incapable of eating foods with colour schemes other than white, black or brownish-grey. The patient, who is colour-blind, comes up with a number of solutions to resolve his shortcomings with respect to chromatic appreciation: he turns to monotonal visual art, he does more things at night, and he chooses food such as rice or yoghurt.

Second session. Project discussion and approach.

Oliver Sacks describes the phases which the colour-blind patient undergoes: state of shock, depression, acceptance and adaptation. How would colour-blindness affect us? What daily habits would we modify? Would it change the way we interact with others? How could we improve the day-to-day existence of a person suffering from achromatopsia? Based on a discussion revolving around these questions, students are presented with the three main goals of the proposed chromatic activity:

- To design an achromatic edible gastronomic experience.
- To explore ways of obtaining achromatic ranges through food and cooking.
- To postulate consistent criteria from the language of colour for plating and staging their gastronomic creations.

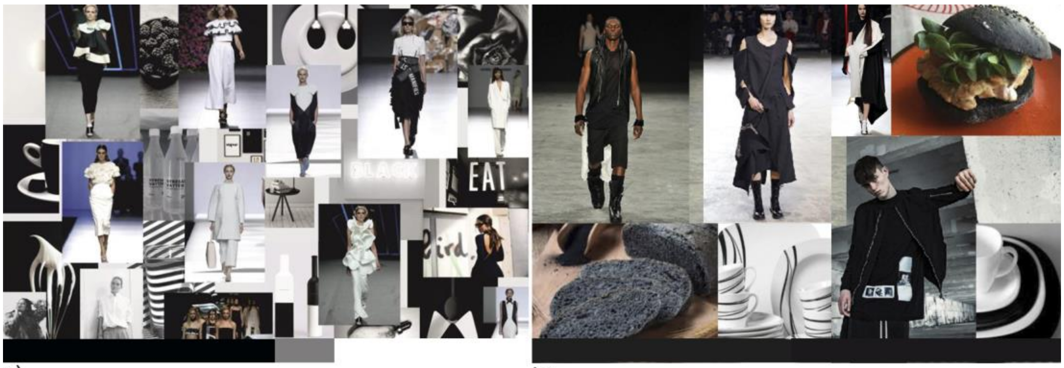
Third session. Visual thinking.

Students present a visual panel that contains graphic information and applies colour criteria based on the proposed requirements (Figure 1):

a) Collection of images, materials and textures chosen according to brightness scales, black and white contrast or hues (white, black, grey and/or brownish-grey). In this way, predominant achromatic hues are obtained.

b) Selection of foods that work together chromatically to execute students' recipes: *white* food (rice, hake, cheese, etc.), *black* food (black pudding, black olives, caviar, etc.), *grey* food (sardines, anchovies, etc.) and food products that tend to lighten or darken when handled.

c) Points of reference from an artist or designer in any field, which inspire them because of the way they manage projects related to the white to black chromatic scale.



a) b)

Figure 1: a) Chromatic scale by contrast of black and white/ Foods: whipped cream and blackberries/ Artist: Chema Madoz. b) Predominant black in a scale reduced to black and white/ Food highlighted: black bread/ Designers: Rick Owens and Yohji Yamamoto.

Fourth Session. Problematics.

The future designers gather together to resolve doubts regarding their own research processes. Doubts are categorised into the most recurrent points.

a) Selection of formats for plating and/or presentation packaging, in keeping with achromatic criteria and enhancing the signature cuisine prepared by the student.

b) Possibilities for treating ingredients and ways to blend foods to obtain varying intensities of grey (warm, cool or neutral).

c) Selection of appropriate achromatic attire for presenting the edible *non-colour* creation.

TASTING COLOUR

The opening session features the presence of a cooking expert, Javier Piña, who makes highly pertinent comments on the work submitted. Students explain their creations and define the guidelines for enjoying the gastronomic experience with respect to the objectives set out at the beginning of the project.

First of all, they present their **edible achromatic experience** design. Students carry out their staging according to the achromatic criteria set forth in the visual panel corresponding to their ideas. The range of proposals encompasses examples of great contrast, grey scales and/or monochromatic ranges of black and white. Colour applications show consistency between the chromatic keys studied and the selection of attire, table styling and the results of the signature dishes prepared (Figure 2).

Figure 2: a) Staging, with predominant highly contrasting black and white. b and c) culinary creations in line with high contrast criteria.

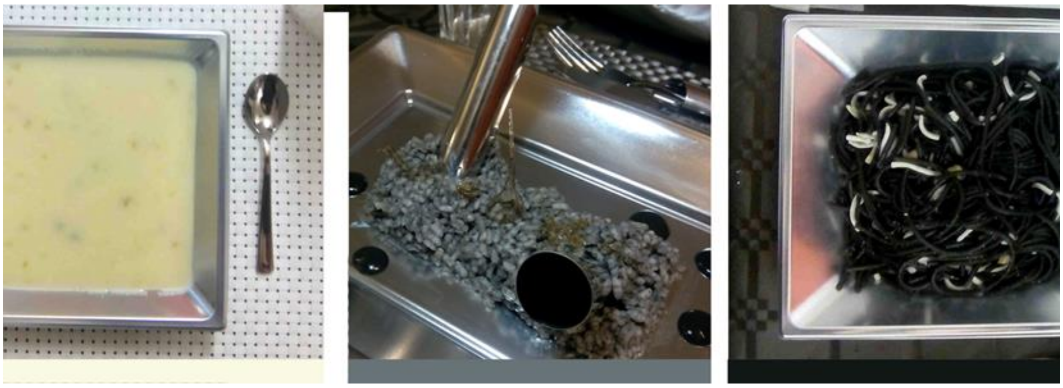
Secondly, the creations confirm the possibility of developing **edible chromatic scales** through the manipulation of different types of food. The presentations reveal diverse ways of obtaining brightness scales to render chromatic variations on the same dish. Figure 3 shows us the results of an edible chromatic scale.

Figure 3: Arranged left to right from greater to lesser brightness. The variation in hue of the container, the *nest*, is obtained using different types of chocolate with varying portions of cocoa. The brightness of the eggs varies according to the ingredient applied as a coating for lightening or darkening (grated coconut, vanilla-flavoured sugar, cocoa powder or cinnamon).

Other chromatic solutions provide a menu that is ordered according to criteria of greater to lesser brightness. The ongredients of the dishes are chosen based on the position they take upon a scale of brightness rendered using food (Figure 4).

Students' ideas for plating and staging demonstrate cohesive criteria based on the language of colour in relation to their achromatic visual panels and research. The selection of plates, glasses, cutlery and tablecloths is linked to the chromatic criterion applied in each creation. To bring the achromatic experience to a conclusion and empathise with a colour-blind person, students design achromatic perception glasses that enable any user to see reality in a grey scale. With this aim in mind, they turn a mobile device into a small display of black and white vision.

Figure 4: Shown left to right from greater to lesser brightness: a) starter, using a hue with a high degree of



brightness; b) first course, medium grey; c) second course, with a low brightness tone.

CONCLUSION

At the end of these experiences, four noteworthy results are obtained. Firstly, it is shown that the use of cooking as an experiential tool functions as a strategy for educational innovation. Secondly, exploration through food unveils new avenues for developing edible achromatic and chromatic scales. Thirdly, far from posing an obstacle, chromatic limitations constitute an incentive in developing imagination and carrying out a design project, in this case based on the concept of *non-colour.* And finally, this gastronomic experience increases motivation and boosts students' active participation and engagement.

ACKNOWLEDGEMENTS

I wish to extend my gratitude to the Escuela Superior de Diseño de Madrid's Colour students who took part in this project; Micaela Uría, a teacher at the Artediez School, for suggesting I read the Oliver Sacks text many years ago; and Javier Piña for his valuable input as an expert in the culinary arts.

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Examining and documenting architectural finishes and surfaces of built heritage

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ABSTRACT
The historical development of built cultural heritage can be clarified by performing an architectural paint research on all finishes and surfaces. Finishes on architectural elements that belong together represent a specific period in history. Finishes can be found on exteriors and interiors of buildings. Each colour scheme incorporates valuable information, not only about the use of colour, materials, and decoration techniques, but also about the historical ways of living, how to represent one's status, and how to create a suitable place to live, relax, raise families, or work. Finding, documenting, and interpreting these colour schemes allows for informed conservation decisions. In this paper, we discuss two developments within the field of building conservation: How both practitioners and commissioners will benefit by adopting a new European standard: Investigation of architectural finishes - Procedure, methodology and documentation and how APR practitioners can work more efficiently with KDTools-APR, a software application.

Keywords: *Architectural Paint Research, documentation, CEN standard, built heritage*

INTRODUCTION
In their annual report, the European Construction Industry Federation states that no less than 26% of a total turnover of more than EUR 100 billion can be related to rehabilitation and maintenance of buildings in Europe in 2016. This number has been a constant for at least five years. Given that number, it is evident that built heritage is under constant pressure to adapt to modern requirements and changes in society.

Built heritage deals with all kinds of objects that were once designed, planned, and created and now have a historical significance for current and future generations. As much of the historical fabric and surfaces risk damage or irrevocable elimination during refurbishment, it has become increasingly important to assure the quality of documentation.

A building survey and especially architectural paint research (APR) can produce a detailed overview of all phases in the history of a building and its interiors. Tracing the historical development in an orderly way, allows for the dissemination of findings to a broader audience and supports informed conservation decisions.

Building conservation has seen a gradual shift in working practices over the past decades. Most definitely, the way to assemble a project team has changed and, at the same time, new competencies have been assigned to participating professions. The decision-making process has therefore changed significantly. This shift in roles, competencies, and responsibilities makes it necessary for new guidelines to be formulated on how to complete a conservation project. In essence, there is a growing demand for agreement on procedures and methods for the investigation and documentation, not only on a national level, but also internationally, to improve the communication with all stakeholders. The task of formulating a 'code of best practice' for APR should involve all professions that are part of the decision-making process concerning built heritage. Such a document, established by consensus, approved by a recognised body that provides for common and repeated use is known as a standard (Nilsen 2017).

In light of these two recent initiatives, the implementation of working procedures as European standards and the introduction of a new digital tool, KDTools-APR to collate findings within conservation projects, will be presented in this paper. These developments make it possible to share and exchange knowledge gained from examinations and research into the 'painted history' and serve as a starting point for a more generous attitude towards the ownership of facts and findings of European built heritage.

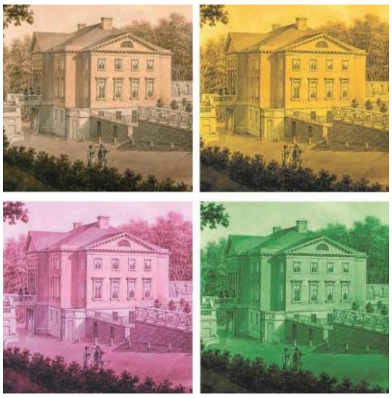

Figure 1: To avoid subjective perception of the historical appearance of built heritage, paint layers need to be investigated in depth before any conclusion on the original colour schemes can be drawn.

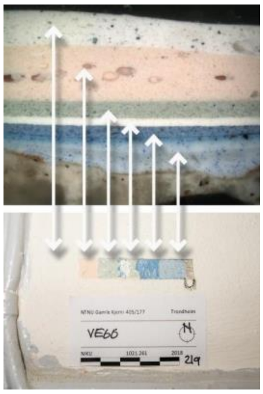

Figure 2: Layered information visualized by a micrograph (top) and uncovering (bottom) showing the layered build of colour schemes.

BUILT HERITAGE

Made in the past and retroactively examined

Understanding the history of built heritage objects provides an insight into our own past, to see how people and communities lived, adapted, moved on, prioritised, and took care of their built environments. They were made by a wide variety of craftsmen, designers, architects, decorators, etc., creating something for a commissioner who wanted to make a statement or to use this new creation for profit, either socially, economically, or politically. Historically, the creation and production process has been organised by guilds or small groups of skilled artists and craftsmen. They had specialised in a particular material and/or technique and were in control of both the production and the trade, to assure a distinct quality. The exchange of ideas, trade of materials, and products resulted in numerous European networks, for import and export, and has been going on for centuries (Spufford 2002).

Many products, skills, materials, and techniques have vanished from the market. Often information about the object is limited, has disappeared, has been forgotten, or is unknown to the current stakeholders. However, most information about the historical colour schemes can still be found during an APR investigation. Architectural elements often contain traces of historically applied material that is either hidden beneath overpaint and rehangings, or that can be found on reused building parts that were displaced during modernisations. Collecting and documenting all of these findings allows for a virtual reconstruction of the historical colour schemes and helps to understand and interpret these 'forgotten' aspects.

Challenges when disseminating results

APR investigators had to come up with their own suitable way to collect and present the outcome of their projects, because no recognised method on how to disseminate findings had been established. Existing documentation requirements serve only as a basis; often the arrangement and interpretation of facts form the main part to produce the necessary insights into the examined object. In addition, the need for a more common approach is desirable to make reports comparable. Limited reports make the communication and dissemination of findings difficult, fact checking impossible, and decision-making unclear. The APR community has been looking for ways to improve the overall quality, encourage work across national borders, and increase understanding of third-party documentation.

TOWARDS COMPARABLE METHODS AND PROCEDURES

International perspective

Within the field of building conservation, a group of like-minded conservators formed a network for architectural paint researchers. Since the 1990s, they have met on both sides of the Atlantic at international APR conferences. (Dorge and Howlett (eds) 1998; CCI (eds) 2000; Hughes 2002; Brenghøi *et al*. 2006; Jablonski and Matsen (eds) 2009; Faulding and Thomas (eds) 2014; Nilsen and Degerblad (eds) 2014; Jablonski and Travers Moffitt (eds) 2018).

In Europe, conferences built on the investigation of both polychrome sculptures and buildings and interiors started in the early 1900s, but really gained momentum in the 1950s, partly as a result of the need to rebuild and (re-)examine the cultural heritage; initiatives back then, however, took place mainly on a national level. The general understanding that reconstruction cannot replace the original was recognised. Since the 1990s, a new international trend is noticeable when (painting-) conservators are opening up to a broader conservation approach by no longer focusing on single objects, but considering treatments on a wider scale, e.g. historical interiors. The scope of intervention during conservation treatments started to include an assessment of all objects, resulting in a more holistic approach. This new approach, and the search for basic requirements and standards for the investigation of architectural surfaces, has been a recurring topic at all APR conferences to date.

European initiative

One initiative towards streamlining the quality of investigation, handling, and documenting of cultural heritage was begun in 2004, when a European technical committee (TC) under Italian leadership was established within Centre European de Normalisation (CEN). CEN is one of three European Standardization Organisations (together with CENELEC and ETSI) that has been officially recognised by the European Union and the European Free Trade Association (EFTA) as being responsible for developing and defining voluntary standards across the European Union. The Conservation of Cultural Heritage technical committee (CEN/TC 346) drafts European standards that will help conservation professionals in their conservation and restoration work. It covers a range of purposes, materials, and object categories. Another goal is to promote exchange of information on results, analysis, and methods across national borders.

Standardisation addresses all parties concerned with cultural heritage, including owners, stakeholders, and users. The experts involved in drafting these standards come from different professional and organisational backgrounds, from architects, custodians, archaeologists, engineers, planners, conservators, craftsmen, conservation scientists, energy advisers, and national authorities to transport and insurance companies. It is hoped that, combining commercial and non-profit interests and making use of both private and governmental sectors, will ensure a sound approach to the preservation and conservation of cultural heritage. Of course, standards have been applied for many years to the construction of new buildings, whereas the use of standards for conservation purposes is a relatively recent development. With regard to industrially produced paints and varnishes, for example, more than 200 standards have been published by CEN and ISO. The equivalent number for conservation of cultural heritage to date is 30.

In 2016, the APR community established a new working group (WG13) within CEN/TC 346, with the goal of drafting a standard exclusively for (architectural) finishes and surfaces, paving the way for increased sharing and comparison of results from APR investigations across national borders. The publication of this new European standard: Finishes and surfaces of built heritage – investigation and documentation (prEN 17259), is foreseen in 2019 and, in the future, might serve as a guideline worldwide via an ISO adaptation.

Figure 3: The number of European standards developed within the CEN/TC 346: Conservation of cultural heritage. The standard currently under public enquiry: Finishes and surfaces of built heritage – investigation and documentation (prEN 17259; in red)

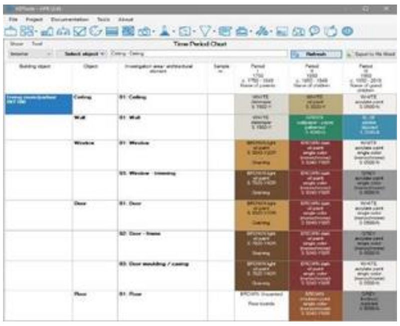

Figure 4: Time Period Chart illustrating a condensed overview of the decorative and painted history of an object, interior, or facade of a building. Screenshot from KDTools-APR application.

Visualising findings from the past

Findings from an APR investigation need to be collated and disseminated so that the historical development can be clearly traced and understood. One initiative, which combined the need for sound documentation with the use of databases, originated in the conservation department at the University in Gothenburg. It resulted in the development of an innovative software application: KDTools, a language-independent documentation tool to collect findings and produce reports

(Edvardson 2011). The functionality and area of the application was later expanded to the field of APR. This application, KDTools-APR, was presented in 2009 at 'Colour Forum' (Färgforum), a network and platform for conservators and architectural paint researchers organised by the Swedish National Heritage Board (Riksantikvarieämbetet) in Visby, Sweden. (Swedish National Heritage Board (eds) 2009). Here, a new outline was presented on how to document, organise findings, link text to images, assign information to specific periods in history, and publish APR reports, all within the same application. The most recent English version was presented at the APR 2017 conference in New York (Verweij and Edvardson 2018).

A key feature in clarifying the outcome of an APR investigation is the representation of the historical development in a condensed overview, in which all dates and findings are combined into a table that serves as an infographic. The original decoration scheme is marked as one (I) and all consecutive colour schemes are noted with an increasing number, depending on the number of modernisations for all architectural elements.

RESULTS AND DISCUSSION

With the introduction of a new European standard and a newly developed software application, the quality of APR investigations will increase significantly. This will benefit all stakeholders, but it will also require a slight change in the professional attitude.

Information about an object should be considered as part of the history of built heritage and be added to previous knowledge. It should not, therefore, matter if information is gathered by an APR investigator working in private practice or someone associated with a (non-)profit organisation, because the main subject is the examined object itself.

The standard can be used to direct the investigation and make sure that no issues are overlooked. Once the raw data and findings are produced, all of this information could then be shared on a commonly accessible platform. Not only APR investigators but also all stakeholders, such as commissioners and heritage authorities, can access the same data, data that were previously hard to obtain and/or interpret. Shared findings can than now can be verified by anyone on the project team, making the interpretation of data less dependent on the investigator in charge. Using the platform, one can check and cross-reference findings from similar European objects. New levels of insight can be generated into the use of e.g. materials, applied techniques, and the influence of fashionable taste, outcomes that, until recently, have been almost impossible to produce.

Because the application is language independent, input can be provided by anyone in their native language. APR investigators signing in from other countries, using their own language, will be able to generate overviews and reports, and use the search functions to retrieve the data. The amount of information that will become available is determined in the public setting of each user. It will be an instrument for quality control because raw data can be compared with already existing, interpreted, and reported data.

Every shared result becomes part of the collective knowledge of built heritage. This allows for interdisciplinary use, inviting other academic fields to use it as a source for a wide range of other research purposes. For example, research into the trade across European borders of products, materials, and techniques that were applied abroad, or research into the exchange of working practices, (re-)use of materials, and imported design features, will certainly benefit from improved access to data.

CONCLUSION

Two European initiatives have led to innovations in the APR working field: a European standard and an APR software application. Both developments aim to standardise the outlining of projects, the basic procedures, and deliverables to improve the quality of APR projects. It will provide for making 'informed conservation decisions' that will positively influence the long-term care of built heritage objects. Quality awareness, especially in those areas where previously monopolists were active on a national level, can now be extended across national European borders, making the outcome of APR projects and their reporting compliant with a common quality and comparable with international requirements.

As a result, the increase in shared knowledge will occur at several levels simultaneously, not only within the field of built heritage but also for governmental bodies, commissioners, etc., for all European countries alike. When similar work ethics apply, and by collating information in a similar way, the raw data become comparable. This means that results will acquire an added value for other research areas and, because the data are searchable, new insights can be gained. This will improve the overall quality, raise the level of the lowest common denominator, and result in a code of best practice that any European standard is aiming for in the end.

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From Colour Café to Speed Dating: 8 experiments and 3 exercises in an advanced colour course

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Keywords: *color education, architecture, interior design*

INTRODUCTION

During the previous decade, Dresden's School of Architecture has become well-known for its color collection and its three-week intensive color module. For one week respectively, students focus on color foundations, color in urban design and color in interior design. In addition to this program, we also offer a number of advanced courses at the graduate level, of which we will present Space|Color|Light at this conference.

Figure 1: Weekly exercise sheets

How can we motivate students, who are accustomed to designing primarily via concept and form and use color merely as an added by-product, to explore the sensual experience of color, material and light right from the start of the design process? How can we teach them to explore color as an intrinsic part of the experience of our world and hence as an integral and necessary part of the process of conceiving design ideas?

In order to awaken the students' motivation to explore the world of color, we have over the years designed a series of experiments, that are conducted with different content during the respective terms. Typically, we use a succession of six to eight exercises during the first half of the course, followed by a design project in the second half.

A. Series of Experiments:

Figure 2: Color Café – Discovering sensual qualities of color.

1. *The Color Café - Sensual Qualities of Color:* To discover sensual qualities of colors, students share platters of different foods and drinks, and by mixing seven to ten colors, compose compositional cords which best represent the sensual memory of the foods.

Figure 3: Producing pigments from different materials

2. *Material Qualities of Color:* Students produce colors from different natural substances (vegetables, fruit, teas etc.), mix them with a variety of different binders (oils, egg, chalk, acrylics etc.) and study the different sensual effects of these combinations.

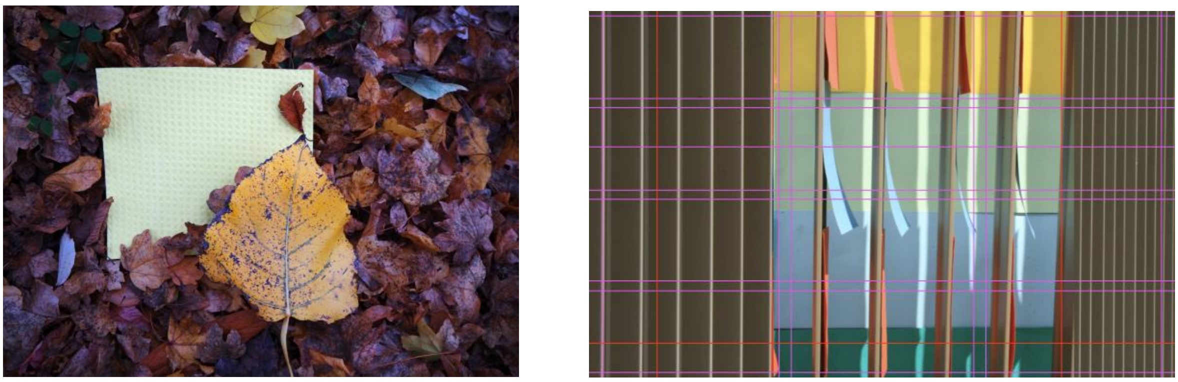

Figure 4: Campus Guerilla

3. *Live and in Color:* Through a series of photographs, students produce visual compositions by placing 15 x 15 cm color swatches in real life settings (interior, exterior, built, natural etc.) and study the impact of this color in the different environments.

Figure 5: Speed Dating – Recreating an atmosphere with colored models

4. *Speed Dating - with Tadao, Steven, Luis & Peter:* Using photographs of spaces by famous architects, students explore the interrelationship between spatial geometry, color, material and light by representing the setting in a model and experimenting with different kinds of lighting, color and material to produce a photo close to the original.

Figure 6: One liter design – Package Design

5. *One Liter Design - Sale Stimulus Color:* How do the colors of a product address the lifestyle associated with it? Using the example of a milk carton, students use the color cords from experiments 1 & 2 to produce different carton designs for varying audiences.

6. *Art & +++ Grasp, Comprehend and Classify:* Works of six artists each from the themes Art & Space, Art & Material, Art & Light serve as examples, that students analyze in regard to the use of color, light and space in their work.

B. Design Projects varying each term:

I. *Analysis - Body and Space:* Views of and from one's own body as a detector of scale, spatial structure, atmospheric qualities are photographically documented.

II. *Content - discover and reinterpret:* Describe aspects students particularly liked and verbalize them in a ‚limbic map'

III. *Synthesis - Function & Appearance:* Determination of functional qualities of the space, design furniture and poster for the first

IV. *One cubic meter of appearance:* Finalization and translation of the most important part of the concept and atmospheric qualities into into a full scale mock-up of one cubic meter of space

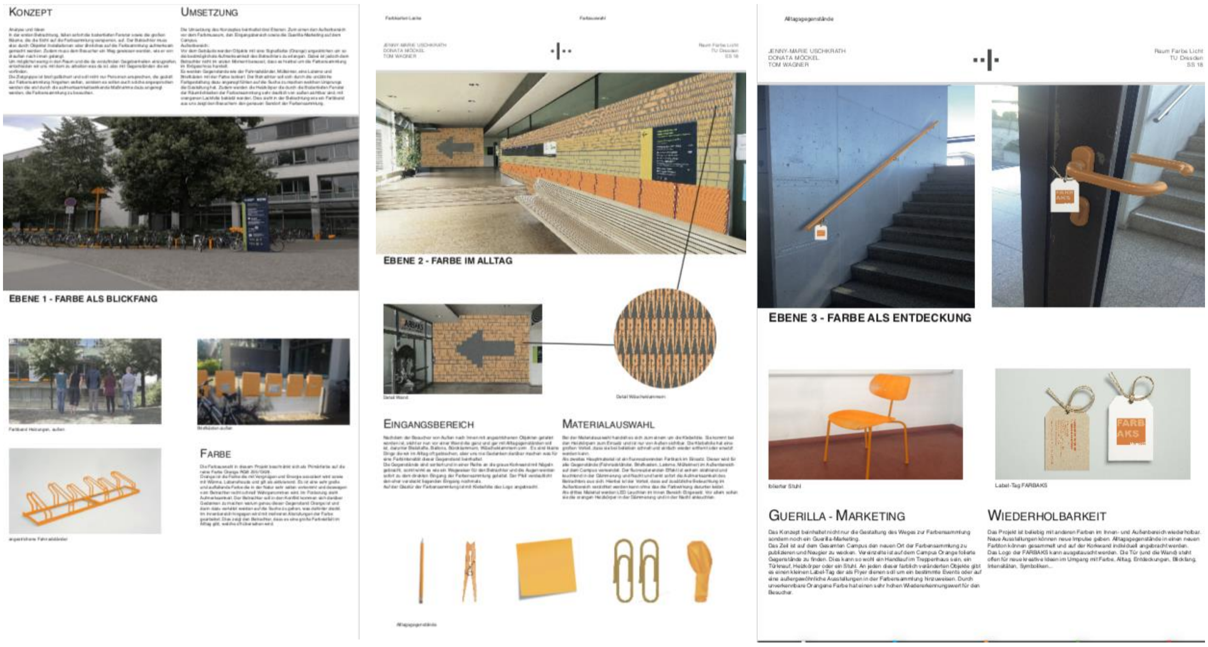

Figure 7: Example of a Group project during the last third of the course

Conclusion:

Throughout the previous ten years of teaching this course, we have noticed strong differences in how an understanding of color and light develops throughout architecture projects and we feel that students achieve a better grasp of how color can be used as a compositional instrument in designing architectural space and form.

Magical realism and chromatic archeology: *the colourist and Procida*.

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ABSTRACT
The subject of the study proposes a crossed look, chromatic voyage, on the island of Procida, located in the south of Italy, off Naples. The purpose of this intervention will be to offer a look in immersion, a documented look, and finally a poetic look at this island territory. Jean-Philippe Lenclos first painted in 1982 the chromatic portrait of Procida. This is the job that will be questioned in writing, as well as issues related to the practice of referencing chromatic data on a territory, from yesterday to today. We will also complete our study by analyzing two works, *Il postino*, a cinematographic work of 1994, by Michael Radford, and Elsa Morante's novel *Arturo's Island*, written in 1957. It is in each of these two works we will capture the other identity of the island. The questions raised by these two authors constitute indeed for us a ground of exploration of the unique and precious territory. *Geography of colour* (jp Lenclos), *magical realism* (E Morante) and *chromatic archeology* (Nacarat-X Ollier) three founding terms in the understanding of the territory, will be crossed and analyzed over the course of the study.

Keywords: *Geography of colour, Magic realism, Chromatic archeology, territory, colourist*

I. Jean-Philippe Lenclos and the colours of Europe

The concept of colour geography is defined by jean-Philippe Lenclos as follows: "Colour is not only a factor in understanding the quality of an environment and a landscape, but also an essential element of its identity, whether it is the architecture dispersed in rural areas, of cities or industrial architecture. As a component of the architectural components, the colour of the different types of habitat is the result of the close interaction of the use of materials found locally and the application of certain colours dictated by the traditions local. This is what we call "the geography of colour. This concept includes the geographical location of a place, its climatic conditions, the geological factors of a region, but also the sociocultural factors of its population. The ranges of colours are very characterized from one village to another, from one city to another, from one region to another and even more from one country to another. "The work of Jean Philippe Lenclos [1] has found its genesis on the ground, and it is actually this part of his work that is remarkable and has made school[2]. Beyond the pallets of synthesis that he put in place, a drawing work, a practice of sketches watercoloured in situ, and a work of surveys in the form of small modules "houses" made it possible to understand the importance of the colours as well as chromatic associations that took place in situ and to consider modeling them. The colour thus typed was able to pass different messages, depending on the language register and the model it then put in place. His space of thought, that of the ground first, then his tools, which he always gathers together, constitutes a scholarly ensemble: the general, isolated palette has no meaning in itself, it exists only by the previous posture that gave birth to him and the photos, sketches and levies associated with it. The genius of Lenclos was born from the recipes, step by step, that he put in place.

Figure 1: Jean-Philippe Lenclos (1938 -) La géographie de la couleur, Italie, (Analyse de site, projet n°1, Procida) , 1982 , Plaka sur papier, collage sur carton, 37 x 37 cm, Don du designer colouriste, 2010, Numéro d'inventaire : AM 2010-1-241 (1).

"Colour is a specialty, it is a precise language, which responds to laws that were, not long ago, poorly known. It's my job to decipher the mechanisms and apply them with analysis and method. Method as objective as possible, it is at least what my works tend to propose without forgetting the intuitive and poetic dimension, essential and always present. "[3] When in 1977, Jean-Philippe Lenclos developed a system of chromatic thought, a method and models, the innovative nature of his approach allowed to give it a deep meaning and to establish it as a reference. Some of his successors, seizing these methods without always questioning them and questioning them in the context of the project, then risked making them inoperative and reductive if they did not see them as a starting point and not as an end in themselves. itself. The job of colourist cannot be reduced to a method that is applicable in all circumstances. It is here the commitment to a thought in action and action that is necessary for a qualitative practice of the profession of colourist, within which everyone must understand the stakes of his own practice, for which he is there and how he appropriates the existing models.

[1].In any case, in his works, *The* colours *of France, The* colours *of Europe, The* colours *of the world*, which constitute a chromatic look on certain regions and certain countries, without being exhaustive. As part of the 3D colour workshop where he officiated until 2005, Jean-Philippe Lenclos was working on methods of chromatic charts completed and whose methods have made reference in the art.

[2] I myself was trained by Jean Philippe Lenclos and his team from 2001 to 2004. So I owe to the 3D workshop my first steps in the job of colourist ..

[3]Lenclos (Jean Philippe), *Géographie de la couleur, De l'analyse de site au concept d'application,* Centre Georges Pompidou, 1977, p.1, In www.centrepompidou.fr consulté le 8 juillet 2014.

In Procida, it is this logic of classification which motivated, 40 years ago, Jean-Phillippe Lenclos in his work of surveys of facades. It's the same work that we did 40 years later. At this stage, first, only some methods of colour classification and modeling have differed. Lenclos will use its small houses, we will use the colour map. Like him, we will use the photograph as a testimony, and we will share the field samples in the manner of the archaeologist, which we will each classify in our own way.

II. Borrowing from archeology: the appropriation of the method Posture, between observation and interpretation: Chromatic archeology.

Figure 2: Procida / colour map.

In reality, the job of colourist is a plural profession and the methodological approaches of site analysis are multiple. Local colour thinking can rely on many creative resources, and these will be more or less "grounded" in concrete data, depending on the project and the postures. As far as we are concerned, it is the place, in the multiple sense of the term "loci", which constitutes the source of study and the very foundation of research. I will borrow from Michel Butor the term *Genie du lieu*, to exemplify my words: The genius of the place, this author defines it as: "Some places are particularly active, revealing parts of ourselves that we did not know, that's what I call their" genius ", relying on the Latin tradition. Often it is because they are shaped by man that they are the materialization of a culture or an era. It is the genius loci in the Latin sense of the term, this protective spirit. At Butor, genius allows us to discover in ourselves things we did not know. A link is created between man and place. But this experience of the place, this "power" exercised by the city on its inhabitants and visitors "[4]

A. The colourist subject perceiving

"The man walks in the yellow burning sand." The place is colour. Man walks in colour as the colourist who makes his markings. The logical perception of a facade, even a space, is based on a sensation. Thus, at first, the colourist perceives a place for the immediate visual sensations that they provide him. Then, his swatches in hand, he practices the matching on the facades, and isolates the data of perception first, the colour which dominates in quantity within the general pallet, and the elements of details on the point pallet. This dichotomy, this intellectual separation of the perceptual data which in space are inseparable, thus goes, by the model, to position the perceptive act as a posture in its own right, which intellectualizes and transfigures the immediate

[4] Butor (Michel), *Le Génie du Lieu* , Paris : Les Cahiers Rouges, Grasset, 1958, p.5.

percept. The colourist works in colour because after having perceived and referenced, it exceeds the shape of buildings, beautiful ironwork, wonderful sculptural details, to go to a singular colourful reading of these particular elements. Of course, it does not brutally split the formal aspects and chromatic aspects, making them inseparable. He will nevertheless make colour his favorite, in the sense that it will be central and will link all the other elements analysed.

Figure 3: Analyse chromatique Procida: Xavière Ollier, 2017.

III. Towards a chromatic poetics, imaginary foods Borrowing magic realism:

"The notion of "*magical realism*", put in place in 1925 by the German art critics about post-expressionist paintings, is now claimed by some Spanish-American authors: the term" real maravilloso "appeared in 1949 under the pen of Alejo Carpentier (preface to his book El reino de este mundo or the Kingdom of this world), refers to a specific worldview in relation to the genres and categories imported from Europe, such as the marvelous, the fantastic or the various "realisms". In the "real maravilloso", the writer tries to undo the reality he is confronted with in order to discover what is mysterious in things, life and human actions. He does not try to copy the reality according to the norms in force, like the "realistic" writers, nor to transgress it freely like the surrealists. Refusing the coded likelihood as much as the fantastic ambiguity, he tries to capture, from within, the mystery throbbing things in a playful aim. [5]

The work of Elsa Morante, *the Island of Arturo*, which takes place on the island of Procida, will fuel our research and motivate our purpose. This work belongs for us to a form of magical realism, and we try here to appropriate this concept as part of the construction of new models of chromatic reception of a place. Beyond the chromatic field surveys, one of the founding elements of local identity is indeed the history of the island, and the relationship that its inhabitants have, historically, with it. In Elsa morante's novel, published in 1957, magical realism carries the place of investiture and the sublime. The book tells the story of Arturo, a young boy who lives on Procida in the post-war period. The story is an initiatory narrative, which makes the island a territory of strong humanity. The island is described through the eyes of the child, but it bears the marks of its history, its geology, its culture. Several places are central, the port, the penitentiary, the facades and in particular the house of Arturo, and the sea. The place is described in a realistic way, and we find as we wander the places of the novel, mediums of fiction. This fiction, however, could be the life of each inhabitant of Procida, just as unique, original, banal, as romanticized. This magical

[5] http://www.larousse.fr/encyclopedie/litterature/realisme_magique/176383

realism takes us on a territory of imagination, but it also tells us a lived space. It enriches us who are only passing travelers, detailed descriptions and island wanderings.

Reading the book, the collected chromatic samples take shape with the place, and the chromatic cartographies take all their sense, fictional, certainly, but lived, by the writer, and indirectly by her fictional character. What Elsa Morante tells us is life on Procida. We take quotes, language, evocative descriptions and colour information that are essential for another analysis of the site. Not the only one of Jean-Philippe Lenclos, who strives to raise the chromatic data In situ, not only that of Elsa Morante, which testifies to the life of Arturo, but a synthesis of these two universes, between reality on the ground and magical realism. A poetic, imaginary and field research, which tries to bring the spirit of the place in its cultural and historical singularity, with the precious help of literary and cinematographic works, with the precious help of the field poet-colourist.

What interest today to develop a growing attraction for the imagination when one is interested in the city and its evolution? Do the multitude of existing cities, past and present, as references and inspirations, in their constructive and projective models not enough to stimulate our creativity? These places, both real and imaginary, open doors that are sometimes difficult to open on real ground. In consulting the work of Alberto Manguel, *Dictionary of imaginary places*[6], it is undeniably an absolute enjoyment to let oneself be carried away by the thousands of places cited, which in turn refer to the imaginary journeys we have made, (or should have done) in novels, cinematographic works, poems or other documentary sources. In reality, these places have an existence in each of these reference works, and what moves us, then, is when we went there and then have a sense of déjà-vu. It then seems interesting to give the example of a territory where we all went in thought at least once: Atlantis. This city built in a circular way, composed of several earthworks which constituted the limits, was evoked by Plato, Jules Verne, Gustave Flaubert and Sir Arthur Conan Doyle, to name only them, seized the myth to give it life. It was then that the myth became a shared culture, and cultural territory of reference just like our historic cities.

Some of these imaginary places constitute a territory of inspiration that emancipates from the rules and "received ideas" of our time. Others in a political posture, seize the imaginary place to denounce practices of the city which are bogged down in the pangs of our time. Finally, the imaginary city is a privileged place that we like to evoke, and that fits in our memories as well as the real place. Do we really know the face of ancient Rome better than that of Atlantis? What relationship do we have with this multitude of imaginary places that invade us through our readings and our cinematographic adventures? In the mass culture that is at the heart of families, children sometimes know better the meanders of Mordor[7] than the city where they live. Fortunately, these imaginary cities also have colours, drawings, scary stories and enchantments and they are in themselves a source of food for the spirit.

[6] Manguel (Alberto), Dictionnaire des lieux imaginaires, Paris : Babel, Actes Sud, 1998.

[7] Tolkien, *The Hobbit or there and back again,* Londres, 1937, but also the latest film: The Lord of the Rings, inspired by Tolkien's writings.

Figure 4: Procida/ Arturo's Island - chromatic analysis.

When fiction becomes source of imagination for work:

The cinematographic work The factor "Il Postino", directed by Michael Radford in 1994 will also support our point. When we came to the island, we quickly realized that the cinematographic work would be for us a singular subject of study. We wanted to analyze the look and the shots, in order to understand the polychromies present in the 1990s. The film as a testimony of an era. But as we wandered around, we realized that the movie was more than that. In the city, signs have been erected, they describe the film and testify to the key spaces of filming and fiction. The film has become on the island a support for promoting space to live, and it is no longer the place that is fictional support, but the fiction that values the place. It is these Games of go-backs between reality and fiction that will motivate our study. Il postino is a fictional work that has been nourished by Procida and that Procida feeds on. This allowed you to preserve the local polychromy, which the inhabitants would have preserved in order to preserve the spirit of the place to better satisfy the memory of the work? It is difficult to know.

Figure 5: Il postino / chromatic analysis.

Conclusion: The poet colourist

The colourist is in the narration: I tell myself stories. The colourist is in the story: "This is precisely the primary role of the story. It opens a theater of legitimacy to effective actions "[8]. This narrative is the one born of action, which opens, gives legitimacy and allows progress. I am then in this tale of the city, I tell the city over my discoveries. The colourist is in poetry: "the objective was to show from specific cases that the function of the poet is not exclusively reserved for writers, but that it can just as easily be provided by visual artists: René Char told us warned for a long time by his passage from writing to drawing and painting that are wandering. "We are warned: out of poetry, between our foot and the stone it presses, between our gaze and the field traveled, the world is zero. Real life, the irrefutable colossus, is formed only in the flanks of poetry". [9]« This quote borrowed from Edmond Nogacki offers the visual artist the opportunity to become a poet, and vice versa. In reference to the work of René Char, then in the practice of the colourist, it is undeniable that the verb and the chromatic form both have the capacity to write a poetic space.

[8] *Op. cit.,* De Certeau (Michel), Giard (Luce), Mayol (Pierre), *L'Invention du quotidien, 1. Arts de faire,* Paris : Gallimard, 1994, p.13.

[9] Nogacki (Edmond), *René Char, Orion pigmenté d'infini ou de l'écriture à la peinture*, Valenciennes : Presses universitaires de Valenciennes, Parcours, 1992, p.381.

Colour as a designer of an urban place: patrimony, identity and tourism in the city of Córdoba, Argentina

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ABSTRACT

In the context of the contemporary city and within the dynamics of urban processes, cultural tourism has acquired a relevant role that impacts on certain sectors by promoting the revaluation, rehabilitation and in some cases, the commodification of certain areas to the detriment of others. At the same time, the patrimony constitutes a value that joins society by creating a sense of belonging to a specific place and group.

In this framework, the intervention of urban chromatic design in Belgrano Street and nearby were an essential element in the history of the sector and the construction's engine of an urban place. Today, it is popularly known as 'Güemes' neighbourhood. The chromatic expression of the facades, the recovery of the modest architectural patrimony, the diversification of commercial and recreational activities, adding to the appropriation of tourists and inhabitants of the entire city, a new identity of the sector was reinforced.

Keywords: *colour, urban place, patrimony, identity, tourism.*

INTRODUCTION

The urban transformations that have occurred over the last decades represent new conditions, both material and contextual. Consequently, in Latin American cities and particularly in Argentine cities, the urban experience and the belonging's relation of the inhabitant to his city have changed. There are new ways of using traditional urban spaces and new collective uses that presume a change in the concept, image and its assessment, and therefore a change of the city.

As one of the structural components of the language of the city, the urban colour provides environmental qualities that contribute to meet the needs and desires of the man in his urban experience and in the construction of sense of place.

COLOUR, PATRIMONY, IDENTITY AND TOURISM: GÜEMES NEIGHBOURHOOD OF CÓRDOBA

The problems of the contemporary city and its spaces are the subject of debate in different disciplines. The different perspectives and approaches take as an object of particular reflection the use and appropriation of urban spaces, sustainability, patrimony's assessment, tourism, among others.

In the case of the Latin American city and in particular in Argentine cities, urban processes show transformations that are expressed in new ways of using urban spaces. For example, Latin American cities have valued their historic centres in order to protect and conserve heritage because it constitutes a value that joins society by creating a sense of belonging to a specific place and group.

In the last decades, rehabilitation and revitalization actions of urban areas have been conducted and have got an architectural, urban and cultural interest. These interventions are based on current conceptions of cultural patrimony that includes the modest patrimony. Also, other cultural events are included that identify these neighbourhoods.

In Cordoba city, Argentina, Güemes neighbourhood is a representative case of these actions. There have been different transformations through the time and in different stages. The changes were characterized by the increase in commercial and residential activity and the appearance of tourism. In addition, it is strategically located in a peripheral neighbourhood near the Historic Centre and next to the traditional neighbourhood of Nueva Córdoba.

Figure 1: Güemes neighbourhood, rehabilitation and revitalization of urban areas.

In this context, the inputs of different disciplines and their different perspectives contribute to define the concept of place. Understanding that in our present condition, spaces, anti-spaces, places and non-places are interwoven, complemented, interpenetrated and they coexist together (Montaner, 1998).

As a result, an urban place is a set of physical-perceptual and significant facts which are the ideal environment for urban life. It includes components trough which this living condition is done to a certain degree from the use, appropriation and load of meaning by those people who inhabit it. Therefore, commercial, residential, patrimonial and tourist aspects, among others, participate in the design and conception of an urban place.

The recovery of architectural and urban patrimony is distinguished in the reinvigoration of Güemes neighbourhood. It could be defined as a complex net in which the secrets were woven at a certain time and they are intertwined between people and the urban environment (Waisman, 1997).

According to cultural tourism, it appears as a culture’s experience and as a communication between visitors and residents. Its current conception also involves the modest and immaterial patrimony as an attraction that enriches that experience and contributes to the identity’s construction (González Viaña, 2006).

In this context, as one of the structural language’s components of the city, the urban colour provides qualities that collaborates on meeting the needs and desires of the man in his urban experience, in the construction of sense of place and in the urban identity’s definition (Avila, 1996)

Consequently, the chromatic expression accompanies and is an active part of the changes produced in life of societies that are demonstrated in different ways in the city and its spaces. The importance of the chromatic design lies in its impact of the perception and daily life of the inhabitants and in the cities’ identity.

Figure 2: The chromatic expression in the 80’s, 90’s and the last decade.

COLOUR AS GENERATOR OF AN URBAN PLACE

The traditional Güemes neighbourhood in the city of Córdoba, historically was characterized as a working-class neighbourhood. At the beginning of the 80s, the ‘Paseo de las Artes’ was created which is a centre for cultural activities as a consequence of new intervention strategies in the city. This promenade was achieved by recovering a group of working-class housing where the colour and new activities gave it an image that was consolidated as an urban landmark by the time.

In the 90's an intervention of urban participatory chromatic design was carried out. The Municipal Government, neighbours of the sector and the Colour Institute of the Architecture's School of the National University of Córdoba acted jointly as regard this intervention. The mainstay of the proposal was Belgrano Street which consolidated the sector as an area of particular physical and socio-cultural characteristics. A new identity of the sector was enforced by chromatic expression of facades, recovery of modest architectural patrimony, diversification of activities of commercial and recreational character and the appropriation of the place by the inhabitants of the entire city.

In the last decade, the increase in the use of public spaces by city inhabitants and tourists enforces the characteristic of urban-scale multifunctional area. There, the residential neighbourhood, the commercial and the commercial-tourism coexist together.

WORK METHODOLOGY

The study of the recent history of Güemes neighbourhood and its urban space hasled to a recompilation work and an analysis of the different urban architectural interventions and the study of the colour's role in these interventions. In order to shorten the research work, a temporary curtailment has been made that covers the period from the 80s to the present.

Different actions were carried out to interpret the colour and to corroborate its role in the definition of the urban place:

- The study of the different chromatic palettes which are used in the revaluation of the place through the time.
- The chromatic survey of the current urban space.
- Conducting interviews with social actors which are directly related to the urban space of Güemes neighbourhood, in different stages of the intervention.
- The observation and registration of the use and appropriation of the real space. Interpretive observations, photographic record and interviews with local users and visitors.
- The development of conclusions by relating the chromatic aspect with the physical-perceptual and experiential-significant.

The results of the work can be summarized in the following statements:

- The creation of the Paseo de las Artes in the 80s and its subsequent recognition as an urban landmark was the result of the recovery of old workers-class housing and the colour palette used. In an urban environment characterized by grey and ochre's desaturation colours, the light pink colour is applied on largest surfaces such as facades and the white colour of the mouldings which are framed in the openings. These became a characteristic and identity component of the neighbourhood.

- In the 90s, an intervention of participatory urban chromatic design was made with Belgrano Street as the structural mainstay. The project has covered 150 private properties equivalent to 1800 meters of facades. A polychromatic system of contrasting harmonic colours was used and this has made possible the enhancement of a patrimony that includes residential and religious architecture and an asylum for elderly people. This intervention has consolidated the traditional handicrafts fairs. Also, it has encouraged the location of commercial, cultural, gastronomic and tourist activities along this mainstay. Thus, the sector was consolidated as an area of tourist and recreational interest with a particular urban identity.

- In the last decade, there has been the expansion of characteristic activities (handcrafts, cultural, commercial and gastronomic) and an increase of the residential activities. Therefore, Güemes neighbourhood has been established as a neighbourhood of interest for local inhabitants and visitors as a result of various interventions that architectural renovations and new typologies were included. The original urban colour was alternated by the expansion of the chromatic palette. The use of saturated colours of different colour ranges together with neutral colours increased the idea of polychromatic and contrast.

CONCLUSION

A new identity of the sector was reinforced by the chromatic expression of the facades, the recovery of the modest architectural patrimony, the diversification of activities, also by the inhabitants' appropriation of the entire city.

In the last decade, the increasing appropriation and use of urban areas by the local community have transformed the neighbourhood into a commercial, recreational and cultural area of urban scale. As a result, it has become a new attraction of the city by diversifying the traditional tourist offer of the city.

To sum up, the particularity of Güemes neighbourhood lies in successive interventions of different scales and the corresponding processes and ideas. In them, the chromatic design, the revaluation of the heritage, manners and local tourism converged as the structure of the urban place and of its identity consequently.

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colour & human comfort

Colour through the centuries. The Major Seminary of the *Sagrada Familia,* Coimbra, from the 18th to the 21st century

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ABSTRACT
The use of colour is highly dependent on style, protocol, and ritual, particularly in religious buildings. Unfortunately, decisions about colour tend to be neglected in the restoration of historical buildings. We developed a five-step methodology to study colour to support technicians in the decision-making process. As a case study, for two years we assessed the intervention of the Major Seminary of the *Sagrada Familia* in Coimbra, Portugal. We developed an integral chromatic study and tests to anchor our decisions, and to find a compromise between past, present and future. We provide guidelines for colour planning, and conclude that building a chromatic strategy should be considered as soon as the project starts, since it will have an impact on how the project itself will evolve. The role of architects and technicians is crucial to guarantee that a global view of the entire restoration intervention will determine the chromatic choices.

Keywords: *Religion, history, restoration, chromatism, methodology*

INTRODUCTION
Making chromatic decisions to balance historical veracity with present-day trends is a challenge in a heritage building context. The preservation and restoration legal framework is usually vague, and despite the existence of some guidelines and recommendations, the technicians responsible for the custody of the building tend to prioritise other aspects, such as building pathologies, structure, construction systems, or the implementation of utility services. This often leaves the choice of colour until last, or even avoided altogether because colour tends to be considered in a subjective perspective, or just as a simple material aspect of the building.

The main building in the Seminary is late Baroque. It was built by order of the bishop D. Miguel da Anunciação and was concluded in 1765. Its design is attributed to Italian architects and master builders Giussepe Antonio Landi, Giovanni Francesco Tamossi and Gian Giacomo Azzolini. Napolitan painter Pasquale Parente signed the frescoes covering the interior church dome. Some decorative elements, such as the chapels' colourful marbles and the iron gates were imported from Bologna. The original building, *Casa Velha* (literally, "old house") had a distinctive Italian style with red ochre lime façades and green railings. At the end of the 19^{th} century (1873-1883) D. Manuel Correia Bastos Pina ordered important works and new symmetric pavilions, *Nova & Novíssima* (literally "new and newest houses"), were built flanking the Seminary in a harmonious composition, following the same styles of the original and still using the architectural language of their era. By this time, the three buildings had white lime plaster façades, which have been maintained (Fig. 1).

The restoration of this complex had to reconcile two facts: (1) it had been listed in 2018 as a National Monument with its own heritage area protection, and (2) despite the fact that it has not been functioning as a catholic seminary since 2012, is a still an inhabited building with an educational, catholic, and residential program.

During groundwork studies, we verified that the maintenance of the building had been based on a poor assessment of materials and colours, often compromising the conservation of unique architectural elements. The nomination for national monument demanded the development of a conservation and restoration manual as a safeguard to preserve the architectural elements as they currently are. However, this manual was not supposed to provide a global view for new interventions or changes.

In this very complex scenario, we needed to establish a solid strategy for chromatism. Colour had to be discussed as a complete subject with specific attention and applied methodology, just as in every other element of the project. We aimed to develop a restoration strategy while giving a predominant role to colour in the intervention.

Figure 1: General view of the Major Seminary of the *Sagrada Familia* in Coimbra, Portugal.

EXPERIMENTAL

1. Historical analysis and site review: Our first approach to immerse ourselves in the subject of colour is through bibliography research and regular visits to the building. Our "colour radar" had to be switched-on from the start. We gathered the scarce historical information related to the building's chromatism. We had access to original documents in the archives for the decisions to change the original red ochre façades to white in the 19^{th} century when the new pavilions were built. Additional information was collected during interviews with the librarians, deans and other key stakeholders.

2. Architectural survey: Production of documentation and drawings through exhaustive measurements, photographic reports, archaeological surveys, and observation of the construction systems. A separate chapter was devoted to chromatism, identifying the colour of the main features in the building (doors, windows, skirting boards, ashlars, etc.). For the Seminary survey we used a standard NCS colour chart and colorimeter readings. Driven by our analysis, we looked for specific evidence, successfully finding the original red plasters and a complete colour stratigraphy of the Baroque iron gates (Fig. 2). We also gathered colour samples of representative elements around the building in a booklet. As a result, we were able to elaborate upon a unique colour palette, a spectrum of green, red and brown tones which turned into the chromatic identity card of the Seminary.

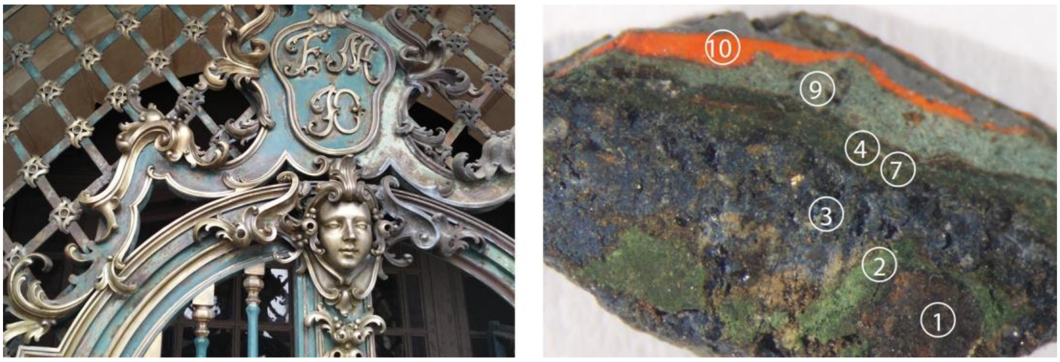

Figure 2: Sample with a complete colour stratigraphy (right) from the Baroque gates.

Element	Sample	Survey (NCS)	Project (NCS)
Exterior spaces: façades			
lime plaster render	4	2030-Y70R	white stucco
wall basement	9	0907-Y50R	ochre stucco
entrance door	8	8010-Y50R	8010-Y50R
windows	5	1020-Y10R	0300-N
window frame, apron	12	7020-Y70R	5040-Y70R
window frame, apron	14	5040-Y30R	5040-Y70R
window frame, apron			5040-Y70R
bell tower beam	19	5040-Y70R	5040-Y70R
bell tower rail	20	6020-G10Y	7020-G10Y
window railings			
entrance door railings	7	7020-B90G	7020-B90G
interior spaces			
staircase doors 18th century	16	8010-Y10R	8010-Y10R
Bishop balcony door	17	6020-Y60R	6020-Y60R
interior church reverse door	10	7020-G50Y	7020-G50Y
corridor shutters 1st, 2nd floors	2	3010-Y	0804-Y30R
hallway skirting board 1st floor	3	6020-Y40R	0804-Y30R
room skirting board	11	8010-Y50R	0804-Y30R
ashlar renders (rooms)	1	1505-Y10R	0804-Y30R
ashlar renders (corridor)	6	1510-Y20R	0804-Y30R
ashlar renders (corridor)	21	2005-Y30R	0804-Y30R

Figure 3: Colour chart of the historical survey (Survey), and proposal for future intervention (Project). NCS stands for Natural Colour System 1950 chart.

3. Concept and detailed design: All the documentation, drawings, and models were produced to fulfil the program needs, to solve the pathologies, and to meet the heritage conservation demands. Based on the historical colour chart, we proposed a new colour chart to make cohesive decisions in the future (Fig. 3). At this point we started fieldwork, including research and tests of materials. We gathered samples of a selected range of wood, steel and stone. The construction workers were trained to master the use of traditional plasters, pigments, stuccos and whitewashing techniques. The test tool to match texture, colour and techniques became crucial to consolidate our intervention strategy, and provided us with empirical elements that allowed us to discuss and agree upon the current colour sensibilities with the technical team and the client.

4. Restoration and conservation work. This phase demanded its own set of tests prior to the final implementation. We assessed how the colour was applied on different supports, finishes (matte, satin, gloss, etc.), textures and effects (marbling, relief, etc.), and evaluated the results in coordination with all the technicians and the client.

5. Maintenance. Preliminary tests were developed in advance to understand the aging process of the materials. The long execution times, which are habitual in restoration processes, allowed us to recalibrate initial chromatic decisions after preliminary results are assessed.

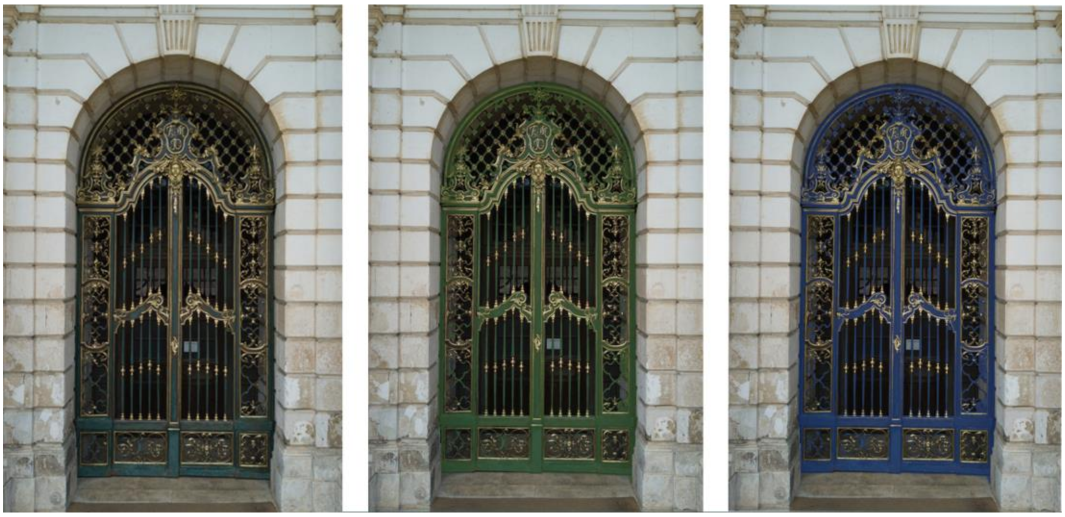

Figure 4: Baroque gates current status (left), virtual images in original green (centre) and blue (right).

RESULTS AND DISCUSSION

The global philosophy of the intervention was to simplify the use of materials, giving continuity to those in the existing building: limestone, wood, steel, and plaster.

For the façade´s renovation, we weighed the possibility of a return to red. However, we decided that it would not have been consistent since the later-built flanking pavilions had never been red. The three buildings had become a new unified entity with its own identity. Consequently, we proposed to maintain the white colour as a "trademark", since white is strongly related to both traditional and contemporary Portuguese architecture.

For the exterior, the goal was to provide a cohesive image to all the façades. To homogenize the windows frames, now in different tones, we chose the red matching the beam of the clock tower, a very typical palette in Coimbra's historical centre.

However, in the interiors we assumed the different tones and dissonances in the public spaces as corridors, refectory, classrooms, etc., and we tried to simplify the tones in the dormitory areas with a more contemporary feeling in luminous tones to improve the quality of life for the residents. For new elements such as the new glass entry door, or the bookshelf in the coffee area, we combined modern sculptural elements with classic colours chosen from our guiding palette, achieving harmonious integration between the old and new. We emphasize the importance of the supports and materials used in the intervention, in addition to the finishings (matte, gloss, satin, stained) in the way colour is perceived. We believe that equally as important as colour is the material that holds it, and the nuances of transparency, brightness and texture.

The Baroque iron gates are an outstanding feature in the Seminary, profusely decorated in bronze. The current paint is very degraded and consists of an irregular *Moss Green* paint from the 1990's. We succeeded at finding a sample from the gates containing the entire stratigraphy, which included about ten tones, all in the green spectrum, and one lapis lazuli blue tone. We elaborated virtual simulations and we decided to propose either the original green and the blue to be tested.

CONCLUSION

The main achievement of this project was to reunite and organize a thread of the history that preserved the identity of the building, and to propose a chromatic intervention that works for a 21st century program.

Our proposed five-step methodology of intervention proved to be a reliable and useful tool. Colour intervention in historical buildings should be based on a detailed analysis of the history of the colour of the building and has to be harmonious with the different colour decisions made by different architects and managers. The final decision will not always be obvious, since different points of history might have been marked by different chromatic choices on different parts of the building.

Chromatic decisions in restoration must take into account the evolution of the building as an impermanent entity that continues to evolve and needs colour choices which are neither disruptive with its past nor with its present intended use.

ACKNOWLEDGEMENTS

Thanks to the University of Coimbra and Gonzalo Pérez-de-Lis Castro for the microscope pictures, to Fernando Cartaxo for assistance with lime plastering, to Sofia Teodósio from Robbialac for support with the colorimeter, to Daniel Montesinos, Emma Crabtree, Lawrence Huntingford and Vicente Zorrilla for language and proof reading.

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Colour and Health

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Comparison of Skin Colour between Healthy Subjects and Patients with End-Stage Kidney Disease

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ABSTRACT
Our research finally aims to explore causal relations between End-Stage Kidney Disease (ESKD) patients' skin colour and blood conditions with their vital data. Therefore, in this paper, we reported a collection of ESKD patients' skin colour, comparison with healthy subjects' skin colour, and the ESKD skin colour change under haemodialysis treatment. As the results, there were large differences of ESKD patients among individuals and measured parts; inner forearm and back of hand. The skin colour of Elderly male's ESKD patients was not much different from healthy subjects' skin colour. On the other hand, the skin colour of elderly female's ESKD patients was darker and more yellowish. ESKD skin colour after haemodialysis had a tendency toward darker and reddish change. But as compared with circulatory dysfunction skin colour differences, there were no significant differences among dialyzed skin colour.

Keywords: *Human Skin Colour, ESKD, Haemodialysis, Spectral Reflectance Factor, CIELAB*

INTRODUCTION
Kidney has four important functions to maintenance of homeostasis, (1) Control of water and electrolyte, (2) Control of Acid-base Equilibrium, (3) Discharge of Metabolites and (4) Hormone Production and Control. First three functions are implemented through formation of urine. The first three functions were implemented through formation of urine. In the process of formation of urine, filtration, reabsorption and secretion of materials are managed in kidney. Finally, urine is discharged out of the body. With decreasing these four renal functions, renal failure is developed, and a lot of symptoms appear. If renal failure deteriorates and becomes End-Stage Kidney Disease ESKD, patients need to be treated with blood purification method.

ESKD patients being treated with the blood purification method are growing worldwide. Japan has about 320,000 ESKD patients, which is the second largest number in the world behind US. Therefore, enhancement of the treatment of ESKD is a top-class agenda and one of the national medical concerns in Japan.

About 80% of ESKD patients in Japan are treated with haemodialysis. Usually, haemodialysis takes 4 hours at one time to eliminate excessive water and electrolyte out of patients' blood, and to supplement necessary materials to survive. In haemodialysis, it is necessary to remove blood in the amount of about 200 ml/min or more. By tapping from the internal shunt that is anastomosis between artery and vein, the haemodialysis patients can remove blood, get rid of waste materials such as water, sodium and urea by dialyzer, supply needed materials from dialysis fluid, and re-transfuse blood into vein.

Haemodialysis treatment cannot be a perfect substitution for real natural renal functions, so patients are required a long-time dietary treatment, medication and attention to concomitant diseases. Normal adults have approximately 8% blood of entire body weight. Water removal amount of one haemodialysis session is ideally from 3 to 5% of body weight. Taking sodium means need for more water. In other words, the weight of haemodialysis patient is determined by the sodium intake. Therefore, doctors instruct haemodialysis patients to practice diet regularly and to limit sodium etc. Medical staff especially nurses rely on their intuitive interpretation whether patients become ill based on observation of ESKD patients' skin colour. Some research reported the ESKD skin colour (Lai 2006), but the skin colour change in worsening health condition is not scientifically quantified. It is a great merit for medical staffs in ESKD patients care to be able to judge patients' conditions from their skin colour without medical staff's personal experience and past trainings, and to be able to convey patients' information to other staffs.

Taking note of the characteristic that haemodialysis makes accurate assessment of body water amount and moving blood pressure possible, our research finally aims to explore causal relations between ESKD patients' skin colour and blood conditions with their vital data. In this paper, we reported three kinds of approach (1) collecting skin colour data of ESKD patients', (2) comparing their skin colour with healthy person's skin colour, and (3) finding out the skin colour change under haemodialysis treatment.

EXPERIMENTAL PROCEDURE

First, the ESKD patients' skin colour under haemodialysis treatment was measured. For this experiment, 17 Japanese ESKD patients (7 females and 10 males) were recruited, and the results of 13 patients over 65 years old (6 females and 7 males) were used for this analysis. They were treated with haemodialysis more than 6 month at Tokai University Oiso Hospital, and don't have other serious conditions. Some subjects have diabetic nephropathy. In the haemodialysis cycle which takes three times a week, the longest gap is at the beginning of the week, and then the accumulated water and waste materials reach a maximum. Therefore, subjects were measured at the beginning of the week.

The two parts of patients' skin were measured; (1) back of hand between first metacarpal and second metacarpal with reference to our previous research (Akizuki 2016), and (2) middle part of inner forearm. Both parts were of patients' dominant arm which didn't have an internal shunt for haemodialysis. Their skins were measured just before haemodialysis, every hour and the end. The measurement locations of both parts were marked with 3cm square holes to stabilize measurement operation. Although we were fully aware of the importance of patients' face skin colour to judge their health conditions, we did not measure their face skin colour to reduce the burden on patients.

The spectrophotometer CM-2600d made by Konica Minolta was used for this experiment. The measurement diameter of CM-2600d was 3mm, light source was D65, mirror reflection was not included (SCE) and viewing field was 10 degrees.

ESKD SKIN COLOUR BEFORE HAEMODIALYSIS

According to previous research (Akizuki 2016), human skin colour data should be separated by gender because of their significant differences.

The results of spectral reflectance factor of each parts and gender are shown in Figure 1. These figures showed large differences among individuals. As the comparison results of both gender groups between inner forearm and back of hand, spectral reflectance factor of inner arm was higher than the one of back of hand.

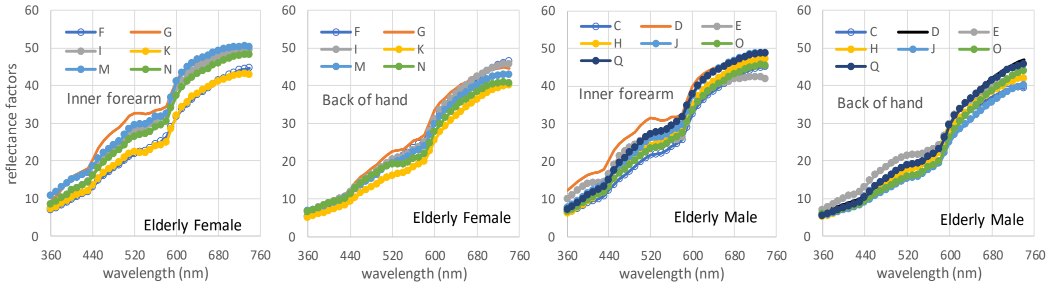

Figure 1: Spectral Reflectance Factors of ESKD skin colour before haemodialysis.

The comparison L*a*b*results between back of hand and inner forearm are shown in Figure 2. These figures also showed large differences among individuals. In addition, they showed large differences among measured parts. The results of inner forearm were whiter (higher L* and smaller a*) than the results of back of hand. Inner forearm may be better part to judge patients' conditions than back of hand in haemodialysis.

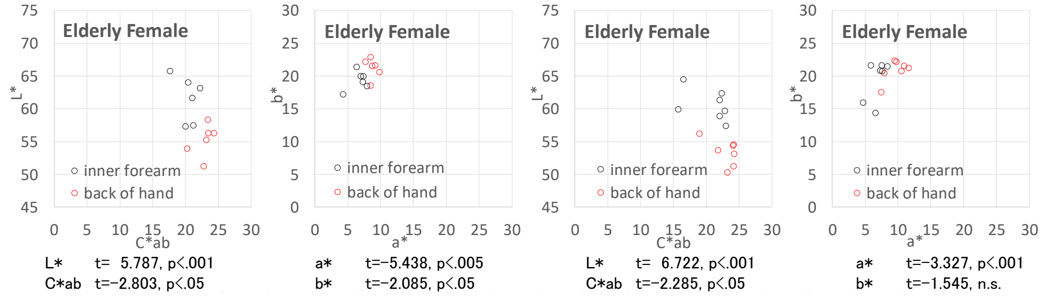

Figure 2: L*a*b* results of ESKD skin colour before haemodialysis.

COMPARISON WITH HEALTYH SUBJECTS

Next, we compare between ESKD skin colour before haemodialysis and healthy subjects' skin colour of our previous research (Akizuki 2016). In our previous research, we were interested in the circulatory disfunction skin colour, and artificially produced the shocked skin colour which was the most prominent symptom in shock with the distal ischemia portion (back of hand) of healthy subjects. Therefore, we used the results at the back of hand for this analysis.

As the results of elderly male's subjects, the skin colour of ESKD patients before haemodialysis was not much different from the skin colour of healthy subjects at L*a*b* colour data. As the results of elderly female's subjects, ESKD patients' results were darker (lower L*) and more yellowish (larger b*). The numbers of subjects were very different, so we should collect more data to judge the skin colour differences between ESKD patients and healthy subjects.

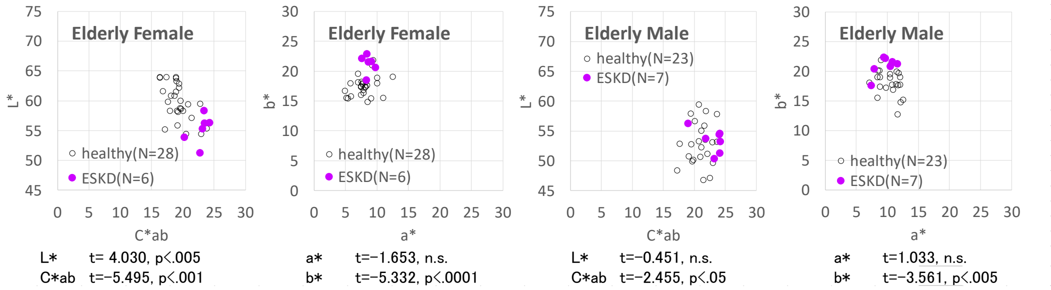

Figure 3: Skin Colour Comparison between ESKD patients and healthy subjects (back of hand).

COMPARISON BETWEEN BEFORE DIALYSIS AND AFTER DIALYSIS

Hourly fluctuation results of skin colour in haemodialysis of a typical subject are shown in Figure 4; Subject-H (Male, 75 years old, Dry weight=68.5kg, Removed Water=2.6-liter, Dialysis period=4 years, and Diabetes Mellitus). Hourly skin colour changed very little, especially the results of back of hand. These hourly fluctuations varied according to individuals. Therefore, we used only two data before and after haemodialysis for later analysis.

Figure 5 shows the comparison results between before haemodialysis and after haemodialysis. Results pointed by red arrows show ESKD skin colour change after haemodialysis was darker and reddish. It is considered this phenomenon was caused by the decrease of the amount of water in the blood and cell tissue, higher Haemoglobin concentration. But the colour differences between before haemodialysis and after were small. And some results pointed by blue arrows indicated the opposite phenomenon. Again, there were differences according to each individual subject, so we should collect more date in further study.

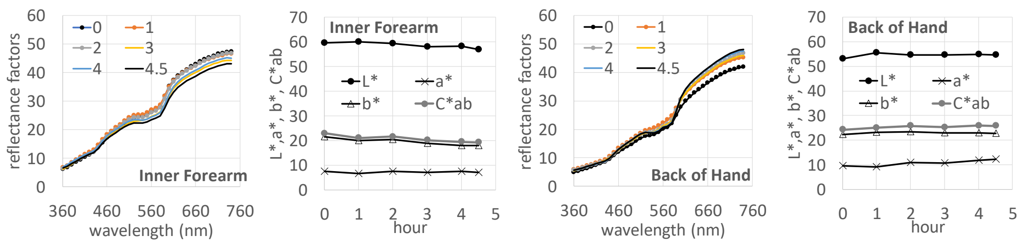

Figure 4: Hourly fluctuation Results of a typical subject's (Subject-H) skin colour in haemodialysis.

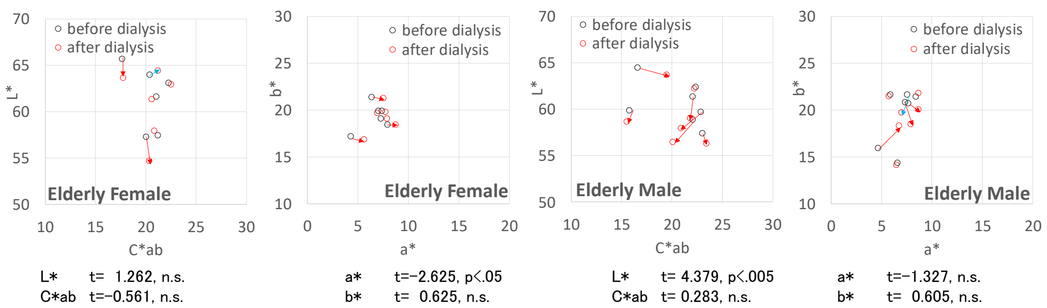

Figure 5-1: Results of inner forearm.

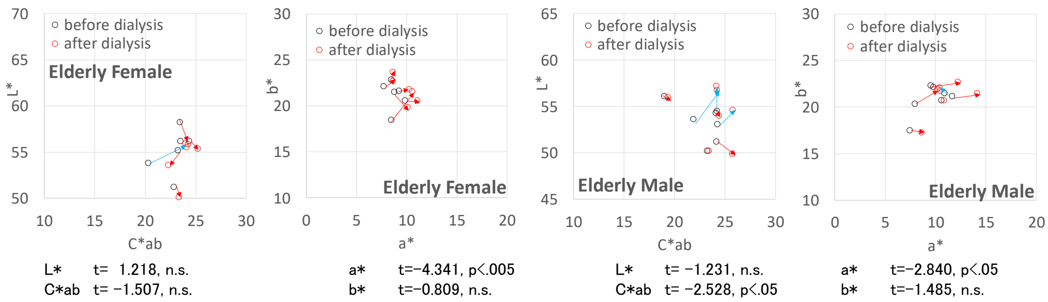

Figure 5-2: Results of back of hand.

Figure 5: Skin Colour Comparison between before-haemodialysis and after-haemodialysis.

COMPARISON WITH COLOUR DIFFERENCES

In our previous research (Akizuki 2016), we found there were large colour differences among different circulatory conditions such as normal healthy skin and shocked skin. On the other hand, there were small colour differences of ESKD skin before & after haemodialysis treatment. These results are shown in Figure 6. It seems to be difficult to judge patients' health conditions in haemodialysis only by visual observation.

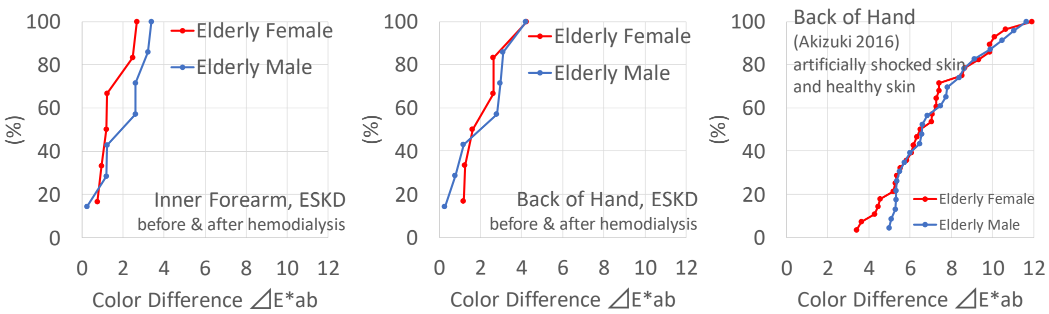

Figure 6: Comparison with Colour Differences.

CONCLUSIONS

We measured the ESKD patients' skin colour in haemodialysis and compared with healthy subjects' skin colour. These are conclusions of this experiment.

(1) There are large differences of ESKD patients among individuals and measured parts.

(2) As the results of elderly male's subjects, ESKD patients' skin colour was not much different from healthy subjects' skin colour. As the results of elderly female's subjects, ESKD patients' skin colour were darker and more yellowish.

(3) ESKD skin colour after haemodialysis had a tendency toward darker and reddish change.

(4) As compared with circulatory dysfunction skin colour differences, there were no significant differences among dialyzed skin colour.

Near the future, we will collect more ESKD skin data and analyze the relationship between dialyzed skin colour and blood test results such as hemoglobin and hematocrit, i.e. concentration of red blood cells.

ACKNOWLEDGEMENTS

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A Study on Stress under Chromatic LEDs in Residential Spaces – Examination of Red and Blue Monochromatic Light Effects and their Subadditivity

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ABSTRACT
In order to use chromatic light in a living environment where white illumination serves as ambient and fundamental lighting, it would be necessary to predict psychological and physiological effects on residents when monochromatic light is mixed with other light. It has already been reported that additivity does not usually hold for suppression of melatonin secretion in physiological experiments. However similar research on stress has not been fully developed. Therefore, in this experiment, we examined the subadditivity/additivity with respect to stress using red/blue monochromatic light whose wavelength ranges do not overlap at all. Based on the analysis on the relationship between irradiance and the HF component of HRV (heart rate variability) in this experiment, additivity of the monochromatic light effects was observed, however, more experimental data will be necessary to conclude subadditivity/additivity for stress.

Keywords: *monochromatic light, chromatic LEDs, stress, subadditivity*

INTRODUCTION

The discovery of ipRGC opens up a pathway to scientifically clarify the process by which spectral light affects the physiological and health aspects of human beings. Around the same time, LED lighting which can emit and control chromatic light easily has been widespread, and not only the biological influence of white light but also that of chromatic light beyond the blackbody radiation limit has come up for discussion.

In order to use chromatic illumination in residential spaces where white illumination serves as ambient and fundamental lighting, it is necessary to predict psychological and physiological effects when monochromatic light is mixed with other light. It has already been reported that additivity does not usually hold for suppression of melatonin secretion in physiological experiments, whereas similar research on stress has not been fully developed. In this study, we will clarify the existence and extent of subadditivity to biological influences by mixing chromatic lights.

EXPERIMENTAL METHODS

In this experiment, we assumed a living room where people spend a longtime relaxing and working. As shown in Figure1, a lighting panel was set up on the wall. Two sofas and a table were installed, and these sofas were slightly tilted to the LED panel so that the gaze of subjects did not intersect during the experiment and the subjects were exposed as strongly as possible to the light of chromatic LEDs. In addition, floor lamps beside the sofas with an incandescent light bulb were used when explaining the experiment protocol to the subjects.

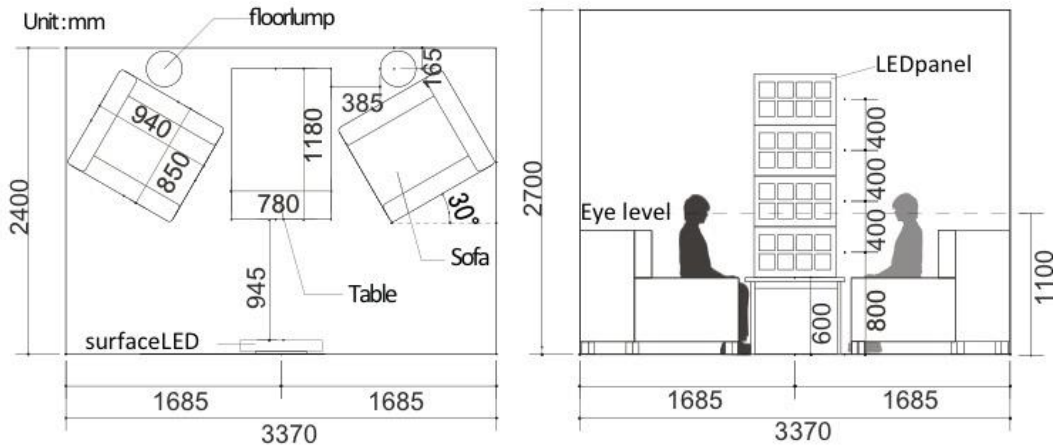


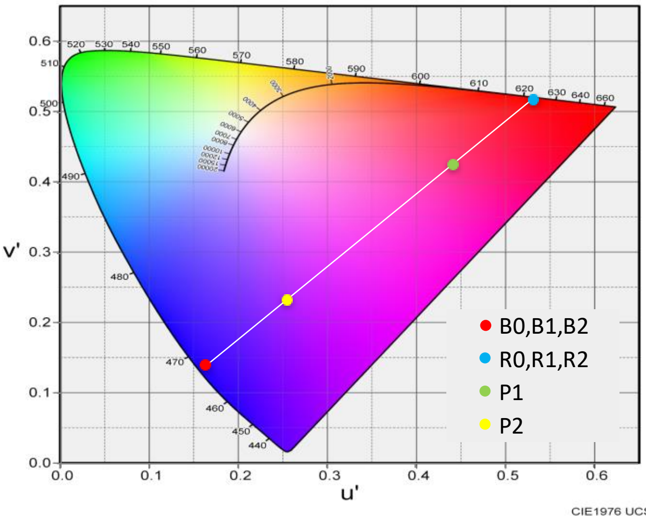
Figure 1: Experimental room.

Heart rate variability was measured using a Wireless ECG Sensor (RF-ECG). The temporal positions of all QRS waves in digitized ECG data were detected with a fast-peak detection algorithm. After all errors in the detection of QRS waves were edited, time series of the R-R interval were obtained. The absolute power of the high-frequency (HF, 0.15–0.40 Hz) components and low-frequency (LF, 0.05–0.15 Hz) were computed, and its power components were transformed into natural logarithmic values.

Blood pressure was also measured using Brachial sphygmomanometer (HES-HEM-IT01J). In order to confirm the response of the baroreceptor reflex response, the mean of the systolic blood pressures of all subjects was determined and compared between lighting conditions.

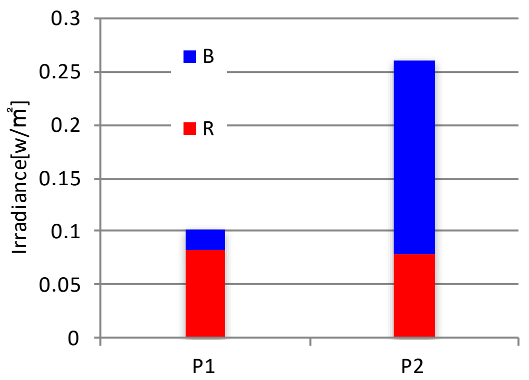
The psychological evaluation sheets were also prepared, and subjects answered the questionnaire immediately after starting each exposure and just before the end of it. The questionnaire was composed of eight items (sleepy/relax/motivate/seeing clear/eye strain/anxious/preference/what's hue) with 9-point scale.

There were eight Illumination conditions as shown in Figure2. Blue and Red lights were used in this experiment and their spectral distribution did not overlap at all, and the dominant wavelengths are 460nm and 629nm respectively. Illuminance was set to 3 levels(15lx,18lx,26lx). Red and blue light with 15lx were named R0 and B0 respectively, those with 18lx named R1 and B1, and 26lx named R2 and B2. Mixed lights P1/P2 were created at the point on the straight line connecting R and B in the chromaticity diagram as shown in Figure2. P1 had the same illuminance as R1 and B1, and P2 had the same as R2 and B2. As shown in Figure3, P1 and P2 had the same irradiance of red light as R0. The irradiance rate of red and blue in P1 and P2 are also shown in Figure 3.



	Illuminance[lx]	Irradiance[W/m²]
B0	14.5	0.25
R0	15.4	0.07
B1	17.9	0.31
R1	17.4	0.08
P1	18.1	0.10
B2	25.5	0.44
R2	27.8	0.14
P2	26.5	0.26

Figure 2: Illumination conditions on CIELUV diagram.



		Irradiance[W/m²]	Irradiance rate
P1	B	0.020	20%
	R	0.082	80%
P2	B	0.181	70%
	R	0.079	30%

Figure 3: Irradiance rate red and blue light in P1 and P2.

31 university students (15 females and 16 males) participated in this experiment, and the average age was 21.7 years old. Figure 4 shows the experimental protocol. Subjects sat on the sofa and performed three tasks (KAPRA, Sudoku, Sketch) during exposure to each lighting condition. Two conditions were conducted in succession at one session. Subjects were exposed to each lighting condition for 50 minutes. Before and after the exposure, they stayed in total darkness for 10 minutes and their heart rate variability and blood pressure were measured (1st measurement and 5th measurement) while subjects were keeping resting states. Heart rate variability was also measured after finishing each task (2nd, 3rd, 4th measurement).

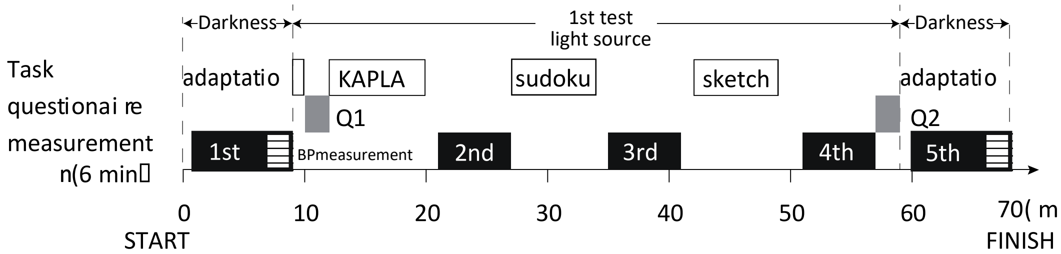


Figure 4: Experimental protocol for one condition.

RESULTS AND DISCUSSION

In the following analysis, stress levels were determined by the increase or decrease of HR and HF values just after the 50-minute exposure (5th measurement) to each lighting condition, compared with those before the exposure (1st measurement). Decrease in HR and increase in HF indicate relaxation. From the measured data in the resting state of 6 minutes, 4-minute data excluding the first and last one minute were extracted and the root mean square was calculated per subject, and then all the subjects data were arithmetically averaged.

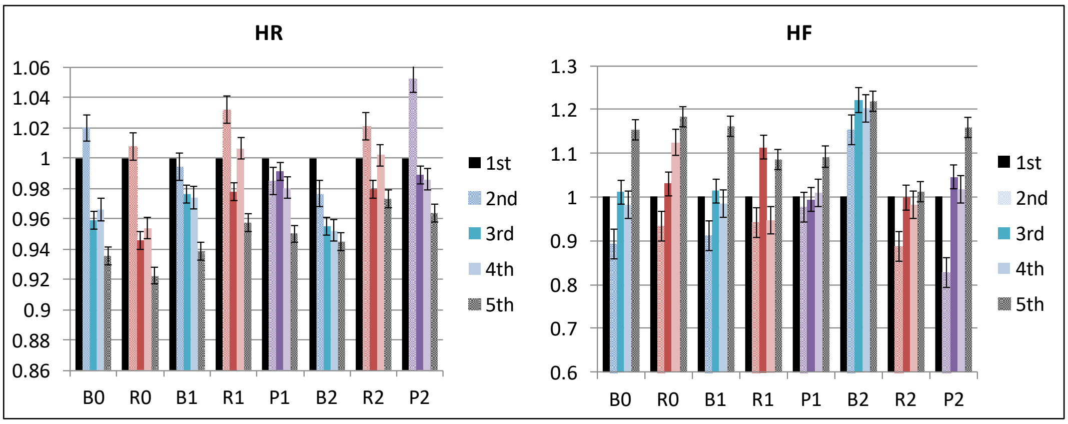


Figure 5: The ratio of HR (Heart Rate) and HF (High Frequency) component.

Figure 5 shows the ratio of the values (HR and HF) to the reference value in 1st measurement. When the illuminance at the eye was the same, red light raised the stress level higher than blue light, which was the same result as the previous experiment. When the illuminance increased, stress level tended to be raised under red light, whereas it tended to lower under blue light, though there were no statistically significant differences among them.

We suspected the influence of baroreceptor reflex under the red light, however, there was no significant difference on systolic blood pressure among lighting conditions and no relationship between blood pressure and stress was acknowledged. There were also no significant differences on psychological evaluations among lighting conditions.

Regarding subadditivity, the following formula generally holds.

$$\boldsymbol{F(x+y) \leq F(x) + F(y)} \qquad \text{Equation (1)}$$

Based on the whole data including red, blue and purple light conditions, Equation (2) was estimated by simple linear regression between the ratio $F(I_x)$ of HF and irradiance I_x. Coefficient of determination of this regression was 0.72.

$$\boldsymbol{F(I_x) = 0.523 \times I_x + 1.00} \qquad \text{Equation (2)}$$

Since the coefficient of determination of the regression line is rather high, it could be said that additivity was observed in this experiment.

CONCLUSION

Based on the analysis on the relationship between irradiance and the HF component of HRV (heart rate variability) in this report, additivity of the monochromatic light effects was observed, however, the range of illuminance/irradiance at the eye was very narrow in this experiment, and more experimental data will be necessary to reach a clear conclusion on subadditivity/additivity for stress.

ACKNOWLEDGEMENTS

We would like to thank ENDO LIGHTING CORPORATION who provided the specially produced LED panel and control system in this study.

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Colour perception characteristics: comparative studies among pre-, peri- and post-menopause women

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ABSTRACT

Women in menopausal transition often face changes of health and mental conditions, perception and cognition. However, the association between menopause and colour perception has been unclear. Here, we experimentally examined how menopause affected colour perception in women. We conducted colour judgement tasks using three face stimuli: happy, neutral and sad, and their scrambled face stimuli, with three colours: red, yellow and blue. Participants were required to judge the colour of a stimulus by pressing one of buttons that corresponded with the colours, and we recorded the reaction times. After we analysed the reaction times of three groups: pre-, peri- and post-menopausal groups, we found that post-menopausal participants reacted to blue significantly more slowly than to the other colours, while no effect of type of emotional facial expression was found. The results may suggest a possible relationship between menopause and colour perception, particularly a deficit of the short-wavelength cones.

Keywords: *visual perception, colour, menopause, emotional facial expression, blue deficit*

INTRODUCTION

Women often experience various changes of female hormones such as estrogen and progesterone during the menstrual cycle and menopause, with attendant effects. For example, some women in menopause have vasomotor symptoms such as hot flashes and night sweats (Judd, Hickey and Bryant, 2012). Some studies have also shown that physiological changes in the menopausal phase could have effects on women's mental conditions, such as depression and deficits in visual perception and cognitive function including verbal fluency and memory (Berent-Spillson *et al.*, 2012; Maki, 2015).

Hormonal changes could also influence colour perception in women, but the association between menopause and colour perception is still unclear. In the ovulatory period during the menstrual cycle, women have better colour discrimination (Giuffrè, Di Rosa and Fiorino, 2006), and in the luteal period, women might experience a decline in short-wavelength sensitivity (Apaydin *et al.*, 2004; Akar *et al.*, 2005). Moreover, middle-aged women who received treatment to control female hormone levels had difficulties in recognition of bluish colour (Eisner and Incognito, 2006). In addition, women are likely to experience different perception of emotional facial expressions as a result of hormonal changes. Women in the follicular phase detected and remembered emotional facial expressions better than those in the luteal phase (Derntl *et al.*, 2008). These studies revealed relationships between changes of female hormones during the menstrual cycle and menopause and perceptions of colour or emotional facial expressions, but how menopause is associated with these perceptions is unknown.

Here, we experimentally examined colour perception in menopausal women using images of facial expressions as stimuli. Colours are often connected with specific facial expressions, such as a happy face with yellow, so we hypothesised that colour perception could differ according to congruent/incongruent conditions between colours and facial expressions, as well as conditions of menopause.

EXPERIMENTAL

Participants

Fifty-nine Japanese women participated in the experiments (mean age and standard deviation, 49.88 +/- 4.96 yrs, range 42-59 yrs). All participants answered a questionnaire about their menstrual cycle or menopause conditions and chose one from pre-, peri, post-menopausal or unknown status. We obtained 23 pre-menopausal participants (age: 46.17 +/- 2.50 yrs, range: 42-52) who had a menstrual cycle, eight peri-menopausal participants (age: 51.13 +/- 3.40 yrs, range: 47-58) who had a transitional phase of menopausal conditions, and 20 post-menopausal participants (age: 55.05 +/- 3.00 yrs, range: 48-59) who stated that their menopausal conditions had continued for more than two years. We excluded one participant whose menopausal conditions had continued only 3 months, four whose status was unknown, and three who had had a hysterectomy.

Stimuli

We used images (250 x 250 pixels) of faces as social stimuli and scrambled faces as non-social stimuli. Face stimuli had three types of emotional expressions: happy, neutral and sad faces, and these three faces were scrambled as three types of scrambled face stimuli (Fig. 1). Each stimulus had one of three colours: red, yellow or blue.

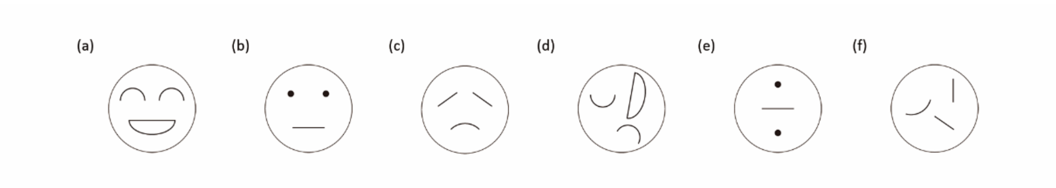

Figure 1: Types of stimuli: (a) happy face, (b) neutral face, (c) sad face, (d) happy scrambled, (e) neutral scrambled and (f) sad scrambled.

Apparatus

The experiments were performed using a custom-made program written using OpenSesame software ver. 3.1.6 (Mathôt, 2010-2016) in Microsoft Surface Pro 2, and using a USB-numeric keypad connected to a tablet computer. In the experiments, participants answered the colours of face or scrambled face stimuli; red, yellow or blue, using the keypad, and their response were always recorded.

Procedure

In the experiments, participants sit in front of the Surface screen (the resolution: 1920 x 1080 pixels) and the keypad on a desk. In a single trial, a fixation dot with 8 pixels radius first appeared at the centre of the screen with a grey background. After 0.5-1.5 seconds, the fixation dot disappeared, and one of either a happy, neutral or sad stimulus appeared in the centre of the screen. Participants then judged the stimulus colour (red, yellow or blue) by pressing the one of three buttons of the keypad, using their right hand, and the positions of buttons were counterbalanced for each participant (Fig. 2). After participants responded, the next trial was started. The experiment included an initial practice and the main phases. The main phases had a total of 81 trials, with three types of stimuli; happy, neutral and sad appeared in any one of three colours, red, yellow or blue, nine times in random order (three types x three colours x nine times). All participants performed both face stimuli and scrambled face stimuli tasks, with a total of 162 trials (81 trials x two tasks). We recorded the reaction times of keypad pressing during the experiments.

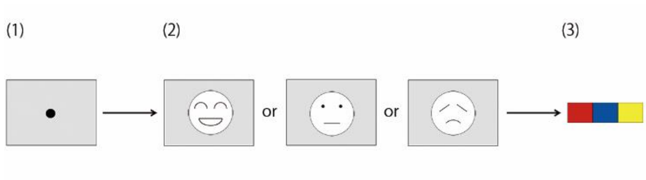

Figure 2: Procedure for the face stimuli task: (1) fixation dot appeared and disappeared, (2) after 0.5-1.5 sec. interval, stimulus (either happy, neutral or sad face) appeared with one of three colours, (3) participant pressed one of three buttons to answer the colour.

RESULTS AND DISCUSSION

After we conducted a multi-way 2 x 3 x 3 ANOVA based on linear mixed models in SPSS ver. 25, we found a significant interaction effect between the menopausal condition of participants and colour in the face stimuli task ($F_{4,\ 381.774}$ = 3.786, P = 0.005, partial η^2= 0.005, Fig. 3a). We also conducted post-hoc comparisons by computing the estimated marginal means, and found that participants in the post-menopause group reacted to blue significantly more slowly than red and yellow, while participants in both the pre- and peri-menopause groups had no significant difference in reaction times to the three colours. In addition, pre-menopausal participants reacted to all three colours significantly faster than peri- and post-menopausal participants, and comparing between peri- and post-menopausal participants, reaction times to only blue were significantly slower in post-menopausal participants. However, we found no significant interaction effects between types of emotional facial expressions and colours.

The results of the scrambled face stimuli task also showed a similar pattern to those of the face stimuli task. The interaction effect between menopausal condition and colour was not significant ($F_{4,\ 386.418}$ = 2.307, P = 0.058, partial η^2= 0.003, Fig. 3b), but participants in the post-menopause group tended to respond to blue slowly. We also did not find a clear interaction effect between types of scrambled face stimuli and colours.

According to the results of both the face and the scrambled face stimuli tasks, post-menopausal women tended to respond to blue more slowly than to red and yellow. In the face stimuli task, peri- and post-menopausal women did not differ statistically in reaction times to red and yellow. These findings suggest that colour perception, specifically perception of blue, could be changed through the menopausal transition affected by changes of female hormones.

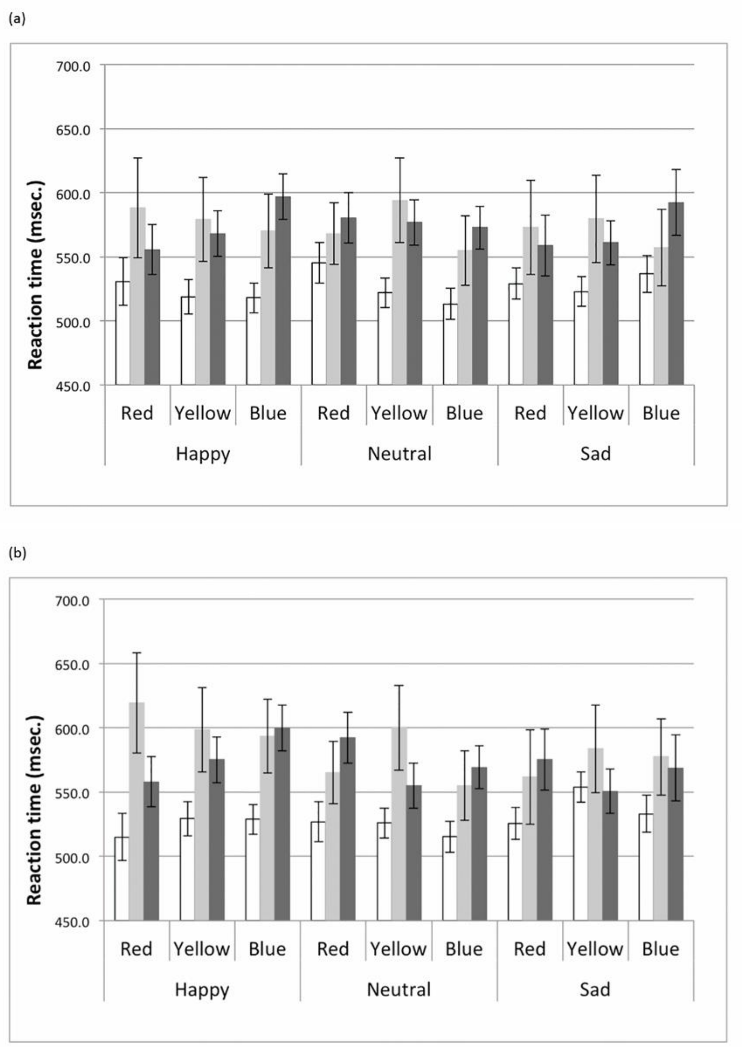

Figure 3: Reaction time (msec.) of pre- (left), peri- (middle) and post-menopause (right) women to stimuli in (a) the face stimuli task and (b) the scrambled face stimuli task.

The differences in blue perception between pre-, peri- and post-menopausal women might be related to the deficit in the short-wavelength detection affected by changes of female hormones. Such a possible dysfunction in the short-wavelength perception has been detected during the menstrual cycle, menopause and hormone-controlled situations (Apaydin *et al.*, 2004; Akar *et al.*, 2005; Eisner and Incognito, 2006; Eisner and Toomey, 2008; Eisner and Demirel, 2011). Although menopause occurs during the course of aging, and we were unable to exclude the age factor of participants, our results suggest a possible association between the menopausal transition and a difference in colour perception, particularly blue perception.

In our experiments, we also expected that participants might experience interference by emotional facial expressions when they judged the stimuli colours, because we generally tend to relate facial expressions with specific colours, such as a happy face with yellow and a sad face with blue. Therefore, in incongruent conditions (e.g. a happy face with blue colour and a sad face with red colour), we expected that the reaction time to colours might be delayed. However, the results did not reveal an association between facial expression and colour; instead, participants judged colours without considering facial expressions, although some studies showed that women might detect and remember emotional facial expressions differently according to hormonal changes during the menstrual cycle (Derntl *et al.*, 2008). The face stimuli used in our experiments were not real faces but cartoon images, so participants might not have focused on facial expressions when performing colour judgement.

CONCLUSION

In conclusion, the results of our experiments revealed the differences in colour perception among pre-, peri- and post-menopausal women, but no influence of emotional facial expressions. Post-menopausal women, in particular, responded to blue more slowly than to the other colours. This phenomenon may suggest that the relationship between menopause and colour perception resulted from a dysfunction of short-wavelength perception caused by changes of female hormones, although aging factors should also be considered. Our findings could contribute to the understanding of colour perception of women in menopausal transition.

ACKNOWLEDGEMENTS

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colour & human comfort

Destinations and Directions: Colour and wayfinding for a dementia ward

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ABSTRACT

Guidelines for the design of dementia care facilities tend to focus on colour contrast, often simplistically interpreted as a contrast in hue. Without the involvement of design professionals, the use of guidelines can lead to homogenous, monotonous and under-stimulating environments. Even as spatial orientation declines as the disease progresses, certain abilities, which allow for navigating space, may remain resilient, and it is accepted that further research on wayfinding using colour and 'landmarks' is required. The paper will discuss a live project for a colour installation within the male dementia ward at the Royal Edinburgh Hospital, with reference to the three main user groups: staff, carers and patients. It will suggest that design specificity in response to place and people, supported by knowledge of the potential of colour to modify space, can enhance the everyday lives and wellbeing of long term building users.

Keywords: *Colour, dementia, wayfinding, design, live project*

INTRODUCTION

This paper discusses a colour intervention at the Pentland dementia ward at the Royal Edinburgh Mental Health Hospital. The design was developed in consultation with a group of patients' family members and nursing staff, and installed as part of an architecture student 'Live Project' led by the author. The project was partly prompted by a sense that, despite evidence-based design guidance, in practice, such 'toolkits' may be interpreted and applied uncritically, often with minimal professional design input, and largely without reference to the specific context. In relation to colour design, dementia care facilities tend to focus on contrast, often simplistically interpreted as a contrast in hue. Although well intentioned, guidelines can be applied dogmatically- leading to characterless, monotonous and under-stimulating health care environments.

DESIGN FOR DEMENTIA

As an architect, a natural starting point for any design is the specific context. This will include the function of existing spaces, the physical configuration, attributes and material surfaces of the building, as well as the environmental qualities of artificial light, sunlight, and orientation. The social context of the users is also a consideration, and in the case of the Pentland ward, this is focused on the care of people with dementia who exhibit high levels of stress and distress. The ward provides accommodation for 12- 14 male patients, most of whom will remain in the care of the hospital for the rest of their lives. Dementia is recognised as a growing societal issue, *'…in 2009, the World Alzheimer Report estimated that worldwide there would be 36 million people living with dementia in 2010, increasing to 66 million by 2030 and 115 million by 2050'* (Downs, M, & Bowers, B 2014, p8). In most cases, it would be preferable to support independent living in community care homes or at home, rather than in a hospital environment, but the Pentland ward patients will have been admitted because of their need for medical and nursing support. The men are all at different stages of the illness, with different abilities and symptoms. Chalfont and Rodiek (2005) have suggested that an inclusive approach to the design of satisfying and pleasurable spaces for all users is preferable to a focus on environments designed to limit challenging behavior in patients.

The ethos of the ward is extremely important, and is summed up by the chief staff nurse,

> '*we are interested in supporting each patient as an individual. What may work for one person, may not for another, but if it works even for just one person, then something is worth doing*.' (Charleston, 2018)

Nursing staff try to remain calm and supportive, often following the lead from the patient, rather than enforcing particular regimes. The ward has taken the opportunity to work on a number of collaborative projects through creative arts organisations, most notably, Artlink, an arts and disability organisation who have a base in the hospital grounds. These tended to be activity-based projects such as the construction of a timber geodesic dome by one patient working alongside a sculptor. The current project shifted the focus from patient activity to the immediate environment of the public areas of the ward. Individual bedrooms are private and so were not part of the project. Unusually perhaps, the chief staff nurse is given authority to operate the ward in relative freedom and readily agreed to the colour installation. He was keen on the idea to break up the monotony of the ubiquitous pale yellow wall colour, to make the environment 'more welcoming for families and staff as well as for the patients' (Charleston, 2018). McManus and McClenaghan, noted that,

> *'…therapeutic environmental design is an important factor in maximising the functioning and quality of life of people with dementia. The quality of the environment has the greatest impact on those with the least physical and/or mental capacity, so good design may compensate for impairment' (McManus and McClenaghan, 2010 quoted in Pollock and Fuggle,(2013), p438)'.*

A key factor for the staff nurse was that a group of young staff had started in the ward in the autumn of 2017, and he felt it was vital to give them a positive formative experience of working with patients with dementia, which they could take forward in their future careers. In addition, the ward was not designed specifically for patients with dementia but had been repurposed two years previously.

Circulation routes were confusing and disorientating, with a long internal corridor, incorporating several changes of direction. Lighting levels are poorer than would be the norm in a purpose designed space. Spatial disorientation and a decline in wayfinding abilities are common early symptoms of the disease, (Marquart, 2011). The provision of distinctive cues at decision making points is noted by Chmielewski & Eastman (2014), while O'Malley, Innes and Wiener (2017) propose that memorable landmarks can act as beacons to aid navigation.

Figures 1 and 2: Circulation before installation, students painting.

COLOUR DESIGN PROCESS

A vital part of the colour design was to develop methods of communication and consultation with users. Although most participants experience the environment of the ward on a daily basis, this familiarity may mean that their observation of the environment is dulled. The first technique adopted for this project made use of a perspective plan view of the ward taken from a simple a three-dimensional computer model. Ward staff and family members in the carer's forum were asked to draw directly onto individual copies of the drawings to highlight specific areas they felt were problematic, and to try to articulate their reasoning. The drawings produced a remarkable consensus, and the design was then able to focus on areas identified most consistently by the users.

At both extreme ends of the ward the corridors terminate in 'dead ends'. In one of these, a dark red and brown doorway to a patient's room attracted other patients who rattle on the door handle, went into the unlocked bedroom, or simply get stuck in the corner (Figure 1). Each instance required a staff member to retrieve the patient and this repetitive activity was clearly identified as a key concern for nursing staff. The rattling of door handles is also noisy and can lead to stressful situations. Although my initial observation was that the men tend to wander round and round, it became clear that, with the exception of the two dead ends, they are not necessarily disorientated, but simply taking the opportunity to walk about the ward. The second most identified issue was the lack of differentiation. This was the case both within the main circulation spaces, and also in the public rooms.

The colour design developed to address these issues, and to reflect the specific architectural and environmental context of each space. Observation included monitoring the sun path, light quality, and room usage. Rather than use architectural plans or computer visualisations, hand sketches proved to be very effective in communicating the conceptual ideas, along with small swatches of possible paint colours. Newsletters at regular intervals kept staff, visitors and carers informed of the project and invited questions. Two themes emerged, which have driven the design response, namely '*destinations'* and *'directions*'. The ubiquitous, pale yellow walls throughout the hospital make every space look similar and feel characterless. Carers emphasised a need for spaces that are joyful, homely and more sophisticated, and small places within the circulation areas where they can sit with their relatives. The concepts behind the design, and the proposed colour palette, were explained to staff and to carers in the ward, after which the sketches were pinned up in the relevant spaces around the ward.

STUDENT LIVE PROJECT

A particular innovation of the project was to involve architecture students in the process of design and installation. The live project was used as an educational tool for students who were studying colour for the first time, and who volunteered to paint the ward. Each intervention demonstrates different potential uses of colour, for example; spatial adjustment, (colour taken round an internal corner to suggest volume and depth); contrasts in light reflectance; defining spaces with different colour palettes to give character; and the strategic placement of decorative graphic motifs within the circulation areas. Finally, elements of saturated colour were used strategically to attract the eye and foreshorten the view.

The students produced large sample panels using rollers and test pots of coloured paint. We then visited the ward so that the students could understand the existing situation, meet the patients and pin up the large sample panels in the appropriate locations. These were left in place for around two weeks to allow all users to experience the proposed palette and how the colour changed through the day and with weather conditions.

Figures 3 and 4: Completed installation.

CO-DESIGN - ADJUSTMENTS TO THE COLOUR PALETTE

As a result of the sample panels, and following feedback from consultations in the ward, a number of adjustments were made:

- the warm terracotta colour was thought to be too dull when seen in the flat light of the fluorescent lights and was replaced by a stronger, brighter red. This request was contrary to the dogma that the colour red has a tendency to stimulate and is therefore not appropriate in a health care context. In the case of this long-term dementia ward, the carers craved a more joyful environment. The existing pale yellow and mustard walls may be perceived as even less colourful by the aging eye. The introduction of vivid blocks of colour at key intersection responded to both these concerns
- The mid green was not popular, while the purplish-grey was universally welcomed. The large panel at the ward entrance was therefore changed from green to the purplish-grey
- during the installation two further adjustments were made to the extent of the coloured panels, in both cases increasing the area of the new insertion as confidence grew.

RESULTS AND DISCUSSION

Feedback from the users was gathered by a questionnaire and semi-structured interview. The most remarkable finding was that the men were no longer prone to stand in the corners. The strong red and patterned panel acts as a beacon and is sufficiently memorable to deflect the patients at the most confusing intersection. 'Incidents', which must be formally reported, have also substantially reduced since the installation. Although this could be due to a number of factors, staff cited that the patients are making more use of the 'living area', which is seen as less institutional and more homely than previously. When staff morale is good, they are more likely to be calm and to take things slowly with the patients, which instils more calmness. Patients will also sit with relatives in the circulation areas as well as within private rooms. The dispersal of the patients around the ward can diffuse tension, and therefore reduces the number of incidents between patients. Since the installation was finished, the staff have added some more graphic elements of their own, such as a memory tree and poems on the wall surfaces.

CONCLUSION

The general thrust of recent research has been to support a shift from a medical terminology of dementia as a condition, to consideration of the quality of everyday living and working experiences for all building users. While published guidance documents may be carefully nuanced in their understanding of colour – this paper has highlighted the need for an integrated approach to colour design beyond the 'tick box' application of a reductive set of principles. In relation to the design of spaces for people with dementia, these may be used uncritically and largely without reference to the specific context, leading to under-stimulating, monotonous environments. The demonstration project considers a more holistic design process, which included the family members and staff in the development of a distinctive design, and the potential for education in colour design through making in a live student project.

ACKNOWLEDGEMENTS

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Saturated Space.
Colour schemes for elderly in Nursing Homes

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ABSTRACT
The aim of this paper is to present a study on how the use of saturated, or strong and bright colours, can improve the environment of nursing homes, and how it affects the behaviour of elderly with dementia. Colour makes a vital tool in establishing safe, explanatory and stimulating environments, but in many Norwegian nursing homes the hues are faint or non-existent and norms of Universal design are not being practiced. Two pilot projects examine specific colour schemes in relation to these issues, seen in connection with light, material and articulation of space, as well as pathfinding and identity. Qualitative data collection methods are used for evaluation, such as discussion groups, individual interviews and recorded observations.
A specific aim for the project has been to either mix paint ourselves or to use special products without the impact of black and titanium white, which both lobotomise the brilliance of hue.

Keywords: *Colour, comfort, stimulation, orientation, elderly*

INTRODUCTION
The backdrop for the initiative is to provide a response to the increasing progress of ageing. The study is linked to my artistic research project at KMD/UiB: Colour between Art and Architecture, which focuses on colour in the built environment, and how Architecture can benefit from Artistic colour practise in terms of quality of hue and materiality. It rebels against the flatness of industrial colour and the use of NCS as a colour mixing system. The main goal in the projects has therefore been to examine levels of saturation in the interventions, with reference to how elderly and patients with dementia perceive polychromy, as supposed to people with normal eyesight and cognition. The projects are also included in the work of a new European network “On Light and Colour in Architecture for the care and wellbeing of older people”. This group comprises

researchers from Sweden, Norway and Spain so far, but the aim is to extend the network. As experts in colour and light in architecture, the Research Group aims to establish guidelines for the chromatic characterisation of different architectural spaces designed for the elderly, and determine perspectives and strategies resulting from the collaboration between institutions and countries. A paper is being presented in Lisbon on this matter.[1]

Master students in design have been included in the projects, as well as in the evaluation process. Staff from the nursing homes have been integrated not just as experts but also as tutors for the students. Finally, Le Corbusier's colour philosophy and practise, including his Colour Keyboard[2] ,has been inspirational for the projects, also as a material method using natural pigments.

THEORY

Sensory deprivation/ Architecture of empathy

Many institutionalized people in the last phase of their lives suffer from chronic stress in the sense that they feel trapped, as in a maze. They often have a hard time with orientation, constantly looking for the way out, or for their room, familiar people, the cat, the kitchen. Together with reduced memory, reduced hearing, movement disorder, cognitive failure and mental problems, reduced vision is very common. This is not being helped with interiors that are drab, unstimulating and in the worst case; sensory deprivating.

In "Phenomenology of Perception", The French philosopher, Maurice Merleau-Ponty, argues in a passage: "Colour in the living perception is leading you into the thing."

In other words: Colour triggers emotional response and gives you courage to identify volume and space, to find your way around. They give you a sense of place.

Esther Sternberg, physician and writer, has been studied in connection with our work. In her book "Healing spaces", and in several lectures, she refers to scientific findings revealing that beautiful views outside a window can make a patient heal faster and reduce medication, as supposed to those who look into a dark wall. It can even reduce aggression in mental states. According to Sternberg, the part in the brain that is activated when we look at a beautiful view is rich in endorphins. From logic, we can draw the conclusion that the same applies to the impact of beautiful, clear hues. Science and experience based knowledge is backing this, and in the future we will encounter forceful evidence in neurophysiological studies.

The fact that we not only see the spread of grayscale in Architecture at large, but also in hospitals and healthcare buildings is therefore worrying. In the case of homes for people with dementia there has been made references to some "alarming" guidelines that dislocate colours as triggers of agitation in the inhabitants. My hypothesis is that this "decision-making" has been done amongst the staff without consulting professionals. As well as being the general "sophisticated trend", black and white is a safeguard within normative guidelines for Universal design, which highlights visibility and pathfinding through luminance contrast (light /dark). Colour is not an issue in this norm and thus no regulations stop environments being achromatic as long as the contrasts are satisfactory.

Another scientific platform has been the research by Helle Wijk, Professor at Sahlgrenska University Hospital, University of Gothenburg, Sweden. Her studies on the environmental impact,

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[1] European Research Group on Light and Colour in Architecture for the care and well-being of older peopleAna Torres-Barchino [a]*, Helle Wijk[b], Mette l'Orange[c], Anna Delcampo-Carda[d], Juan Serra-Lluch[e], Karin Fridell Anter

[2] The *colour* palette by Le *Corbusier* offers 63 fascinating shades that he created in two *colour keyboards* in 1931 and 1959.

including colour, on patients/elderly concludes that architects and designers can contribute more if they work closer to researchers. She found that people in her test group with either old age (80-95) or dementia could discriminate hues with 86 % agreement.

She also points out that colour can enhance recognition, a sense of togetherness, health, circadian rhythms, sleep, activity and wellbeing. It can prevent loneliness, disorientation, confusion and passivity. She concludes: “Colour can contribute to a person centered health, or rather a person and space centered wellbeing.” The idea that saturated colours are dangerous triggers of aggression and that colour contrast (as supposed to luminance contrast) is of no value for elderly, should therefore be rejected. In order to obtain measurable results on this matter in our studies, colour should: Manifest space and give clear definition of shape/ form, create Identity, create atmosphere/aesthetics, create awareness and psychological response, clarify encoding, signage and orientation.

EXPERIMENTAL

Both projects were organized as a prolonged workshop for master students in interior design and visual communication, with group work, lectures and practical experiments. Several lectures were organized as part of the workshop, to ensure a research based platform for better knowledge and understanding of the situation ahead.

RESULTS

Study 1. Gullstøltunet Nursing Home, Bergen

Gullstøltunet nursing home was built in 1992 and is in good condition. It is situated in a suburban area with greenery and a park surrounding the buildings.

It has 90 residents with a permanent place and private rooms with bathroom and toilet. The nursing home consists of five divisions, of which three minor divisions are for residents with a dementia diagnosis, mostly old age. The nursing home also has a separate day ward with 20 rooms, with the capacity for 60 users. It has a general acceptable standard in the common areas, but the floors with the inhabitants were in strong need of a change. They did not reflect the norms of universal design, nor those of homely, yet safe and stimulating environments. The walls were decorated in a yellowish white colour, with doors in three different faint hues, one for each corridor, light blue, yellow and green. Such bleak colours are not recognizable as identification, nor do they give enough physical presence and contrast to the surroundings. They are standard doors and you find them in most nursing homes in Norway. The lighting was poor and ill suited, with downlights and wall lampets. Especially the down facing light in the ceiling made a substantial glare on the floor. The staff in the different sections also complained about dark figures and forms enshrined in the linoleum. They were perceived as holes in the floor by the inhabitants.

The project was a cooperation between KMD and Gullstøltunet. Project leader from KMD: Mette L´orange, Professor of colour. Project leader Gullstøltunet: Eva Maria Lim, director. Three student projects were presented and evaluated. Each project had different ideas and potentials, elements from all projects were therefore transformed or directly implemented, rather than one specific scheme. Focus was both on defining a colour scheme that would give new identity to the different areas in the pilot project, as well as conceptualizing pathfinding, sign/naming systems. Design tools were basically colour, material and light. Coloured niches in the corridors were painted with gradation from dark to light within the same hue. Doors in contrasting colours.

Handrails were contrasted against the wall. Paint quality was highly pigmented paint from kt COLOUR from Switzerland, with the recipe from Le Corbusier.
New lighting has been installed, and floors will be shifted to wood imitation to give a more homely atmosphere.

From Gullstøltunet, whites and yellowish greys are being replaced by saturated colours. Floors are being shifted soon.

Study 2. Bergen Red Cross Nursing Home

Bergen Red Cross Nursing Home AS is a private non-profit institution owned by Bergen Red Cross. The nursing home receives grants from the City of Bergen. It was opened in 1969 and had at the time room for 248 patients by contemporary standards. Many changes have happened since then, the nursing home has today 174 patients divided into eight departments with single rooms. There are two sections for people with dementia, one short time section and one palliative department in addition to the somatic departments. There is also a day ward with 30 to 40 users.

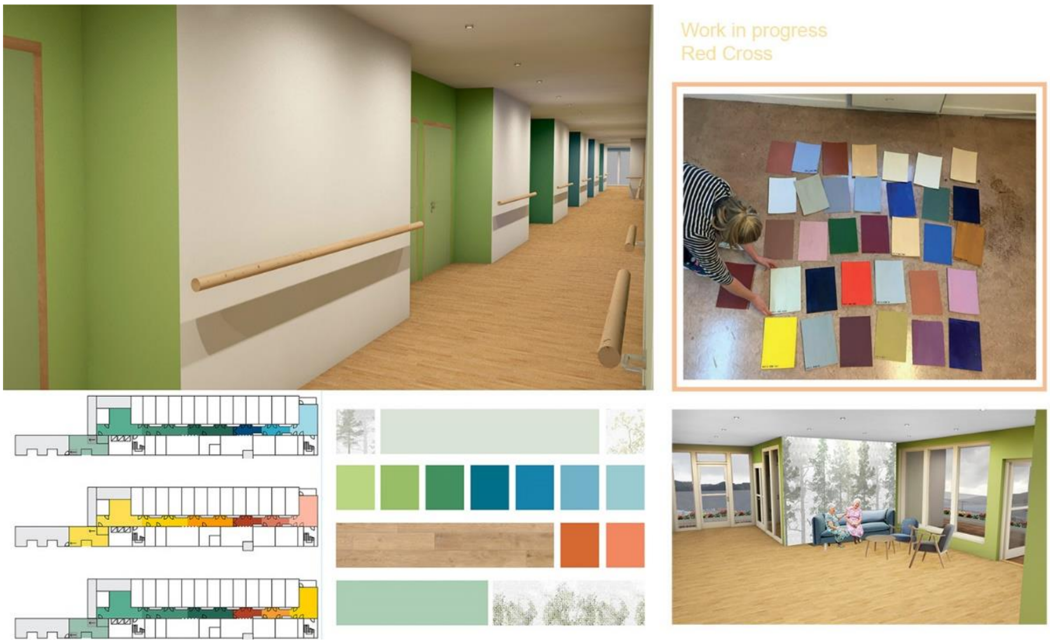
The vision is that the nursing home should be comfortable, have higher aesthetic values and offer a good atmosphere. Unfortunately, the physical interiors as present does not reflect or help that vision come true. The staff in the different sections, especially those that work with inhabitants diagnosed with dementia, are finding people walking restlessly in the hallways without really locating necessary targets as the kitchen, the common room, their own doors etc. There is also a lack of homely touch in these areas. On the contrary, there is a strong institutional feeling as well as a lack of contrasts and colours.

The lighting is not tailored for the purpose. This results in a substantial glare arising from the floors. Signage is absent or randomly placed if it exists, there is not a unified system that provides an overview for family, visitors or the staff itself.

The leadership of the institution had decided to do some serious changes over time starting with the colours and light in the common areas. The project is being executed these days and is a cooperation between KMD and The Red Cross Nursing home in 2015. Project leaders from KMD: Mette L´orange professor of Colour and from Red Cross NH: Britt-Vally Løvstakken

The groups focused on three different floors with elderly inhabitants. One of the floors was a somatic division, the two others for people with severe dementia.

The aim was both to improve spatial conditions in the existing institution, as well as conceptualizing pathfinding, sign/naming systems and the creation of brochures or apps for communication. Conversations with the staff and some family members gave useful information. Their participation was vital for the discussion and selection of project ideas for future implementation. As a result, colour contrasting schemes will be introduced on all floors in different ways. New flooring, wallpaper with motives form nature, plants, some new furniture wherever possible, and personalized signage systems.



Phase 1: Colours for corridors and common rooms. From the Master project at Red Cross Nursing home, Bergen.
The paint for the walls will be hand mixed by the famous Bergen based painter Norbert Seidel.

CONCLUSION

There was a huge emotional appreciation from staff, seeing now the possibility of important improvements coming through in both schemes. Gullstøltunet finished its pilot in 2016. It was financed by The Municipality and KMD research funds. Inhabitants evaluation: Better orientation, atmosphere, sense of identity, lighting improved. No reports of agitation or irritation. The project has initiated further colour initiative. Currently a report is being made. The Red Cross pilot will finish during the autumn of 2018. It has mainly been financed by a local sponsor. Qualitative data collection methods for evaluation is ongoing in this project, so far positive feedback, also from inhabitants.

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Colour Emotions of Japanese Subjects for Antioxidant-Enriched Virgin Olive Oils

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ABSTRACT

With the strong trend in consumption of health foods in recent years, virgin olive oil has become popular. Olive oil is sold also at the countries which don't take olive oil. In addition, in order to make a more healthful oil, it is tried to put lutein into virgin olive oil.

The aim of this study is to understand the colour emotions of Japanese subjects on olive oil including lutein, through the similar experiment conducted in the previous study. Another aim is to know the difference between Spanish and Japanese results.

This study was conducted in Japan looks for relationships between 9 specific colour emotions applied to a set of extra virgin olive oils, to compare with Spanish results obtained a previous study. The olive oils, which have been coloured by using a lutein and 1-carotene enriched extract from microalgae, are the same to the olive oils used in the previous study. In addition, a questionnaire survey was conducted for knowing about the recognition of Japanese consumers to olive oil.

The results of the visual evaluation test were similar to the Spanish results obtained in the previous study. Both of Spanish and Japanese subjects don't like reddish olive oils. However, the difference of the 'Like-Dislike' of Japanese subjects for the samples was a little smaller than that of Spanish subjects. There was a high correlation between some pairs of emotions whose meanings were more related to colour preference. Through a factor analysis, two factors were found as 96.85% cumulative contribution rate. One of the results obtained by the questionnaire survey was that the most excellent point of olive oil is 'good aroma'.

Keywords: *olive oil, antioxidant-enriched, health, colour emotion, visual evaluation test*

INTRODUCTION

Virgin olive oil is one of healthful oils. The olive oil is popular in European countries, but it was not so popular in other countries. However, the consumption of the olive oil has been increasing recently in some countries by health consciousness. International Olive Council (IOC) announced the total of consumption of olive oil including the virgin olive oil in the world has been increasing. Especially, the olive oil consumption of countries out of Europe has been increasing. In order to make a more healthful oil, it is tried to put lutein into virgin olive oil.

In a previous study (N. Rodrigues, et al. 2015), it was analysed about how the colour of virgin olive oil changes when we add lutein and β-carotene enriched extract. In addition, it was tried to know how Spanish subjects perceive the change in colour by using semantic differential method (L. Gomez-Robledo, et al. 2015).

In this study, it was tried to know how Japanese subjects perceive the change in colour using the same olive oil samples and the similar visual test to those conducted in the previous study. In order to know the colour emotions for olive oils and their relations, a factor analysis was used. In addition, a questionnaire survey was conducted for knowing about the recognition of some Japanese consumers to olive oil.

EXPERIMENTAL

Six samples of different extra-virgin olive oils were used. In addition, each one of these samples has adding different concentration of extract microalgae: 0.00 mg/ml, 0.10 mg/ml, and 0.21 mg/ml. A total of eighteen samples have been used, 6 oils x 3 concentrations. Each one of the samples was poured into bottles with dimensions of 1.5 cm X 1.5cm X 6.0 cm and a capacity of about 20 ml. These samples were the same to the samples used in the previous study.

A visual evaluation test using the same experimental method to the previous study was conducted to twenty Japanese students (10 males and 10 females). The visual evaluation test was conducted using semantic differential method with ten sensory word pairs: 'Aromatic- Odourless', 'Bitter-Sweet', 'Fresh-Rancid', 'Healthy-Unhealthy', 'Like-Dislike', 'Natural-Artificial', 'Spicy-Non spicy', 'Tasty-Insipid' and 'Textured-Smooth', also 'Deep-Pale' added in this test. For each pair, they had to choose one of the descriptors and after that they had to decide if that descriptor describe the oil as "a little", "moderately" or "very". For example, an oil can be described as: moderately aromatic, a little bitter, very rancid, moderately unhealthy, very dislike, very artificial, a little tasty, very textured and a little deep. Each one of the samples was shown to each observer 3 times, following a random order. A total of 1080 judgements were made (20 observers x 18 samples x 3 replicas). Photos 1 and 2 show the visual evaluation test and the olive oil samples, respectively. In order to know the colour emotions for the olive oils and their relations, a factor analysis using the visual evaluation results was used.


Photo 1: Visual test conducted in this study.

In addition, a questionnaire survey was conducted to know the recognitions of Japanese subjects for olive oil. 28 Japanese (10 males and 28 females) joined the questionnaire survey. The subjects are not the same to those who joined the visual test.

Photo 2: Olive oil samples used in a visual evaluation test.

RESULTS AND DISCUSSION

Figure 1 shows emotional responses for each sample in scale Like-Dislike: Spanish result obtained in the previous study is left (L. Gomez-Robledo, et al. 2015), and Japanese result is right. X and Y axes are lutein concentration of sample and z score of visual evaluation, respectively.

The results of this visual evaluation test were similar to those evaluated by Spanish subjects through the previous study. Both of Spanish and Japanese subjects don't like reddish olive oils. However, the difference of the 'Like-Dislike' of Japanese subjects between original and reddish lutein-added samples was a little smaller than that of Spanish subjects. The difference of the 'Like-Dislike' of Japanese subjects among 6 kinds of olive oils was also smaller than that of Spanish subjects.

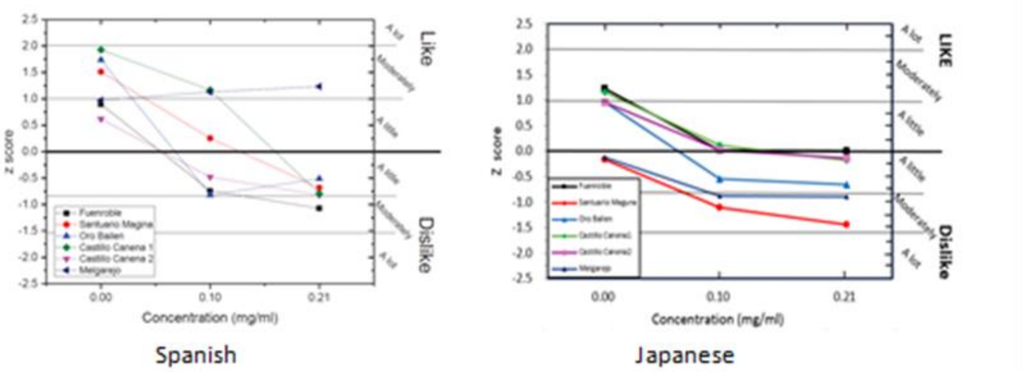

Figure 1: Emotional responses for each sample in scale 'Like-Dislike': Spanish result obtained in the previous study (left) (L. Gomez-Robledo, et al. 2015) and Japanese result (right), respectively.

Table 1 shows correlation coefficient (r^2) of z scores obtained from visual evaluation tests. There is a high correlation between some pairs of emotions whose meanings are more related to colour preference ('Tasty-Insipid', 'Aromatic-Odourless' and 'Fresh-Rancid') in the both of this and previous studies. There is also a high correlation between some more pairs, such as 'Fresh-Rancid' and 'Healthy-Unhealthy', 'Aromatic-Odourless' and 'Tasty-Insipid'. 'Deep-Pale' added in this study has high correlation to 'Fresh-Rancid' and 'Healthy-Unhealthy'. That means that when an oil is perceived as Fresh it is perceived also other colour emotions excluding 'Bitter and Spicy'.

Tables 2 and 3 shows the results of the factor analysis. Two factors were found as shown in Table 2. The first and second factors had 80.36% and 16.59% cumulative contribution rates, respectively. Totally, it was 96.85%. Table 2 shows the contribution of each sensory word pair. The first factor was mainly contributed by 'Fresh-Rancid', 'Tasty-Insipid', 'Like-Dislike' and 'Healthy-Unhealthy'. The second factor was contributed by 'Bitter-Sweet' and 'Spicy-Non Spicy', but 'Spicy-Non Spicy' contributed for the first factor more than the second one.

Table 1: Correlation coefficient (r^2) of z scores obtained from visual evaluation tests. Upper table is the Spanish results of the previous study. The lower table is the Japanese results of this study. Yellow and green cells show correlation coefficients larger than 0.8.

	Aromatic Odourless	Bitter Sweet	Fresh Rancid	Healthy Unhealthy	Like Dislike	Natural Artificial	Spicy Non spicy	Tasty Insipid
Bitter Sweet	0.02							
Fresh Rancid	0.68	0.06						
Healthy Unhealthy	0.73	0.05	0.98					
Like Dislike	0.71	0.04	0.96	0.98				
Natural Artificial	0.73	0.03	0.98	0.99	0.98			
Spicy Non Spicy	0.00	0.66	0.19	0.19	0.16	0.16		
Tasty Insipid	0.87	0.00	0.83	0.87	0.86	0.86	0.05	
Textured Smooth	0.05	0.43	0.43	0.40	0.39	0.39	0.78	0.19

	Aromatic Odourless	Bitter Sweet	Fresh Rancid	Healthy Unhealthy	Like Dislike	Natural Artificial	Spicy Non Spicy	Tasty Insipid	Textured Smooth
Bitter Sweet	0.37								
Fresh Rancid	0.86	0.17							
Healthy Unhealthy	0.72	0.04	0.94						
Like Dislike	0.94	0.28	0.94	0.85					
Natural Artificial	0.62	0.00	0.85	0.96	0.74				
Spicy Non Spicy	0.27	0.06	0.55	0.71	0.37	0.81			
Tasty Insipid	0.96	0.27	0.94	0.85	0.98	0.76	0.40		
Textured Smooth	0.88	0.56	0.81	0.59	0.85	0.46	0.18	0.86	
Deep Pale	0.71	0.14	0.90	0.85	0.77	0.79	0.61	0.79	0.74

Table 2: The contribution of each sensory pair for two factors.

Sensory word pair	factor1	factor2
Fresh-Rancid	**0.994**	-0.008
Tasty-Insipid	**0.982**	-0.144
Like-Dislike	**0.976**	-0.157
Healthy-Unhealthy	**0.973**	0.209
Aromatic-Odourless	**0.938**	-0.266
Natural-Artificial	**0.932**	0.337
Bitter-Sweet	-0.402	**0.898**
Spicy-Non Spicy	-0.741	-0.606
Deep-Pale	**-0.888**	0.426
Textured-Smooth	**-0.938**	0.060

One of the interested results in the questionnaire survey was shown in Figure 2. The question and answer were 'What is the excellent point of olive oil? Please reply by multiple answers allowed'. The most frequent excellent point of olive oil, which fifteen subjects replied, was 'good aroma'. The second excellent point was 'good for health' and 'good taste', which eight subjects replied.

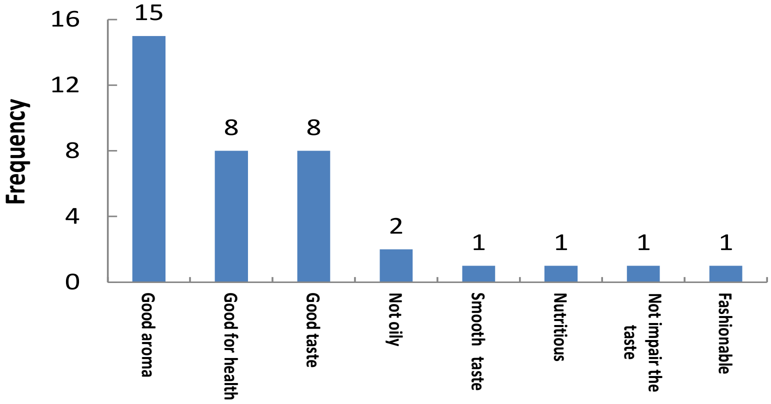

Figure 2: Excellent point of olive oil by multiple answers allowed (n=28).

CONCLUSIONS

In order to understand the colour emotions of Japanese subjects on a set of olive oils including lutein-added olive oils, a visual evaluation test was conducted in Japan. The results of the visual evaluation test were similar to the Spanish results obtained in the previous study. Both of Spanish and Japanese subjects don't like reddish olive oils. However, the difference of the 'Like-Dislike' of Japanese subjects for the samples was a little smaller than that of Spanish subjects. There were high correlations between some pairs of emotions whose meanings were more related to colour preference. The number of the high correlation emotion pairs was larger than that of the previous study. Through the factor analysis, two factors were found as 96.85% cumulative contribution rate. The first factor, which most of emotions contributed, has very high cumulative contribution rate. These analysed results mean that Japanese subjects had similar evaluation on more emotion pairs than Spanish subjects, especially among emotion pairs relating to colour preference.

One of the interesting results obtained by the questionnaire survey for Japanese subjects was that the most excellent point of olive oil is 'good aroma' and the second excellent point was 'good for health' and 'good taste'. This result is relating to the results of the visual evaluation test, and it also estimates that aroma, health and taste are the keywords for Japanese consumers.

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Colours scenarios for senior´s wellbeing in leisure activities

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ABSTRACT
As elderly population increases in number, with economic and health problems, in (un)developed societies, it´s urgent the adaptation of environments and their sustainability (safety, efficacy, efficiency). Aimed to meet the United Nations goals by 2030 with the "Product Design", in an inclusive/ergonomic way, the present research intends to explore the surrounding colour effect and assumes the importance of the elderly leisure in an urban society - as constated in the state of art. It´s important to reach the answer: When in leisure, what will be the behaviour of the Portuguese elderly (influence on wellbeing) vs. colour parameters in the environment?

Keywords: *Senior, Colours, Performance, Leisure, ONU2030*

INTRODUCTION

As elderly population increases in number, but with economic difficulties and health problems, in developed societies and expectable to grow in undeveloped ones, it is urgent the adaptation of the environments and their sustainability - assuring safety, efficacy, efficiency (ONUBR, 2018).

Aimed to meet the UN/United Nations goals by 2030 (numbers 3, 10 and 11 respectively, "*Ensure a healthy life and promote wellbeing for all, at all ages…Reducing inequality within and between countries...Making Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable*" - ONUBR, 2018) with the Research Unit of CIAUD, at Products Design level (aimed to develop methodologies/techniques for designing models - CIAUD, 2018), designing themselves in a project of inclusive and ergonomic spaces way, and exploring the element «colour» in environments, assuming the importance of elderly leisure in an urban society (Nunes, 2016).

It is intended to make the following research question: When in leisure, what will be the behaviour of the Portuguese elderly (influence on wellbeing) vs. colours parameter in the environment?

The article intends to present the postdoctoral research (Lisbon School of Architecture – University of Lisbon) to the scientific community, namely the study methodology, the objectives, the present phase development, some expected results and harvesting enriching inputs from the peers.

Methodology is assumed to be mixed, based on a quantitative and qualitative basis (content analysis - Bardin, 2009) and using User-Centered Design methodology by interviewing/inquiring the senior population (where a representative sample will be needed).

THEORY

As mentioned by the UN, by 2030 almost 60% of the world's population will live in cities and with long longevity facing better living conditions and medical increase's inputs but bringing, among others, social concerns.

Thus, it is proposed to investigate the behaviour of the elderly in relation to the role of environmental colour, exploring these scenarios (mainly in indoors), inducing bio-psycho-social wellbeing, inherents to the health concept according to the WHO/World Health Organization (USP, n.d.).

Related to Portugal and according to INE 2003 data, it is mentioned that in 2000-2050 it will increase the female senior population by 16.4-20.4%; and 13.1-16.1% in men. So, another question to be investigated would be whether or not there is a basis for a research on the level of gender-differentiated behaviour, regarding the colour parameter.

As well as methodology research, colour and seniors wellbeing is the chosen propose for this paper discussion approach.

Note that our life is fulfil with colour - vegetal and animal kingdom (e.g. trees, bees) or inert materials (e.g. rocks). But some of us don´t receive that information because born blind, is daltonic or with the age process the vision process may collapse.

Life satisfaction and his quality may be achieved by creating environments that use colour assertively. For that reason, there are many studies around the colour and never are too much once it is a complex matter, diverging in fields like: Health, Psychology, Physiology, Lighting, Coloumetry, Built Environment, Arts/Design, Culture, Landscape, Digital Colour, etc.

«Colours change life» will be the mote of the tend posdoc investigation. At the end of the process it is expected to verify that senior leisure activities/performance are better by introducing correctly colours in the space like senior residences/daily centres/elderly homes.

EXPERIMENTAL

With the aim of constituting a consistent sample, a newsletter is made (powered by sendinblue®) to invite the institutions, through directors to participate in the study - giving consent to it, with the possibility of getting more information and/or to cancel new approaches (as European «RGPD Regulation» assist after May 25th of the present year) - Figure 1. Follows the translation.

> "Hello!
> My name is Claudia Nunes and I am developing an investigation inserted in the Post Doc in Design (Lisbon School of Architecture – University of Lisbon).
> I am researching the "Design of Spaces" and I am asking institutional authorization to be able to carry out a study in the area of Senior Spaces and Colour (forward needing to interview/inquire elderly people volunteers in your institution).

Through research, it is intended to contribute to elderly population wellbeing. With these "small" contributions - divulgating reports and giving lecturing as designer/researcher- I try to emphasize the need to include them, in the process of designing spaces (according to the User-Centred Design Methodology), i.e. assuming the importance of taking inferences by doing user´s interviews/inquiries (to know their preferences, motivations, limitations, etc.).
So, I would like to invite your institution to take part in this academic study and to constitute a country sample – so i will need that you click on the green button below or just in (this link) here.
However, at any moment you may give up of this study or ask me for more information through claudianunes@hotmail.it (link).

Thankfully,
Arch.des. Claudia Nunes

I wish to participate in the investigation

This e-mail was sent to (your) E-MAIL for considering the great interest in your services and so that the investigation can be carried out with the largest number of elderly homes/residences/day centers in the country.
(Please) click here if you do not want to be contacted in the future"

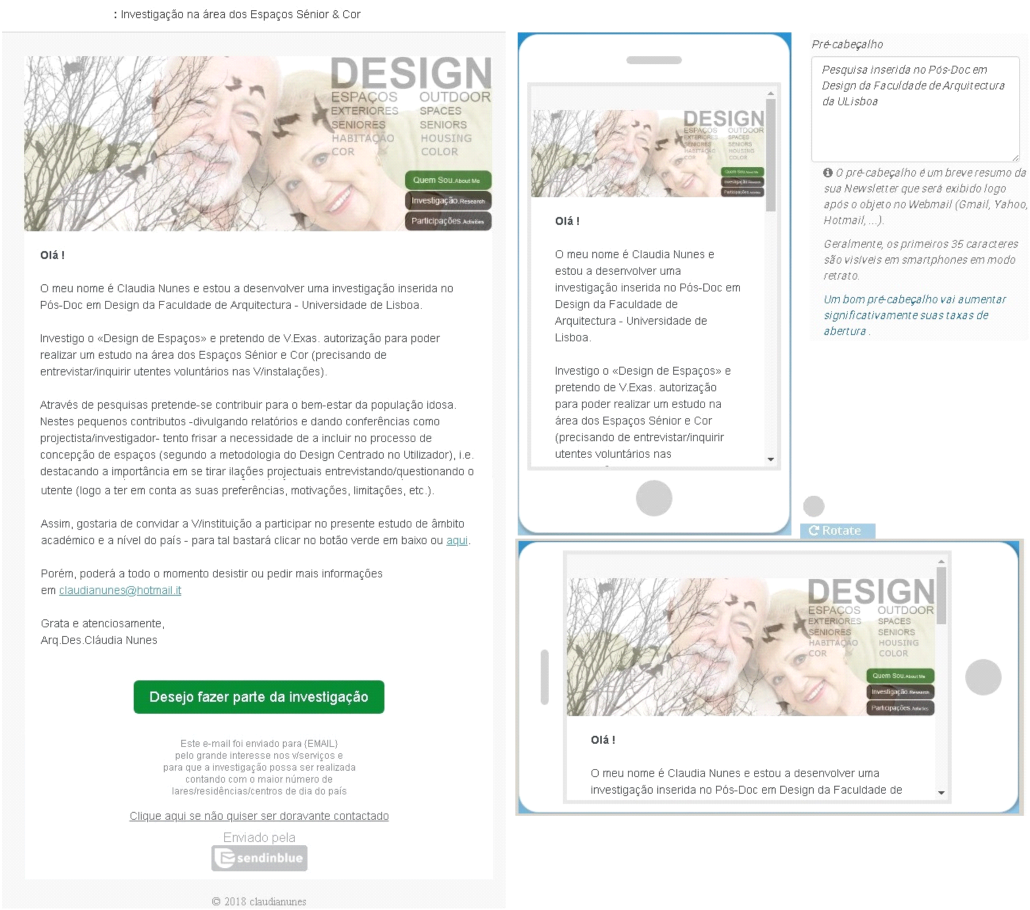

Figure 1: Newsletter (inviting institutions to the research) visualized by computer and mobile

RESULTS AND DISCUSSION

With the «social letter» available from private Elderly Home Association it´s possible to send by e-mail information/newsletters about the study, to each Portuguese associated institution (N=179).

There is a research time-consuming process, motive that makes it ambitions, desirable and yet unknown at Portuguese data base.

The next step will be to consider the sample legible, otherwise, another list will be needed.

Statistically, a random of it will be made and just some elderly homes/senior residences/daily centres institutions will be aleatory chosen by a specific software. Then, in each institution, interviews/surveys with questionnaires will be made presentially to senior volunteers. Questions concerning «Colour» will be made and motive of another research paper approach.

CONCLUSION

Beside some health and economic issues, world elderly population increases, signal of nowadays time: medicine advances and better living conditions. And what about wellbeing and life quality?

It is urgent to adapt the environment to people and do not be people to be forced to adapt to the surroundings.

Inclusive/ergonomic environments must be guided by safety, efficacy and efficiency and «colour» assures it for sure, if well applied. In the literature panorama there´s a question not already answered: When in leisure, what will be the behaviour of the Portuguese elderly (influence on wellbeing) vs. colours parameters in the environment? The present research intends to answer it.

ACKNOWLEDGEMENTS

Many thanks to CIAUD-FAUL (Research Centre in Architecture, Urban Planning and Design - Lisbon School of Architecture – University of Lisbon) for supporting this paper presentation and to Professor Fernando Moreira da Silva as co-author/adviser. As well to Professors Jorge Ribeiro and João Pernão for the statistical inference and colour research inputs, respectively.

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Colours of Wellbeing – The Colour Forecasts of Intercolor Finland

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ABSTRACT
Colours can affect our feelings of wellbeing based on the conceptions and ideas we relate to them on a personal and cultural level. Past trend colour forecasts give an outlook on the societal aesthetic values and collective colour preferences of the targeted market. This paper discusses the connection between wellbeing and colours in the colour forecasts of Intercolour Finland by examining the conceptual and visual relation between colours and words. The methods used to acquire data were thematic analysis and semi-structured interview. The analysis revealed that wellbeing is a frequent theme in the forecasts, and it can be further divided into subthemes that are all characterized by distinctive groups of words. The colours related to wellbeing can be categorized in three ways: according to subtheme, hue and lightness and saturation. The colours most often related to wellbeing were light and represented the group of green hues.

Keywords: *Colour conception, wellbeing, conception of wellbeing, trend colour forecast, Intercolour Finland*

INTRODUCTION

The paper discusses the connection between wellbeing and colours in the trend colour forecasts of Intercolour Finland (Suomen Intercolour Yhdistys ICfin Ry). Colours can affect our feelings of wellbeing, mostly based on the conceptions and ideas we relate to them on a personal and cultural level (Arnkil, 2013: 244). Language and verbal concepts guide our perception of the world and give meaning to visual elements (Kay, 1978: 611). Colour forecasts give information about colour trends and consumer opinions of the near future. Past colour forecasts offer a view on the societal aesthetic values and collective colour preferences. The forecasts of Intercolour Finland offer a comprehensive view on the continuum of colours used in Finland and the change in them from 1978 to present day. This makes them an invaluable source of colour information that has not before been studied in Finland.

The goal of the study is to uncover how colours and words relate on a conceptual level in the colour forecasts. It provides a systematic analysis of colours and words that expands the understanding on how they relate on a verbal and visual level in the context of wellbeing. The questions the study searches to answer are: What does wellbeing mean and how does it appear in Intercolour Finland's colour forecasts? What is the connection between words and colours describing wellbeing? Which colours in the forecasts represent wellbeing?

For this paper, well-being is defined as an individual's desired state of mind that consists of different positive elements of mental, physical and social dimension. The definition is formulated based on official definitions of wellbeing from different institutes; National Institute for Health and Welfare of Finland, Institute for the Languages of Finland, the health library of Duodecim, a medical journal, and the World Health Organization.

EXPERIMENTAL

To find answers, a thematic analysis and three semi-structured interviews were conducted. The data for the study was acquired from Intercolour Finland's colour forecasts from season spring/summer 1995 to spring/summer 2018. The colour forecasts consists of approximately 30 colour swatches that are divided to 3-4 themes. Each theme has a short description of the idea and essence of the colours in question.

Interviews with colour specialists and members of the Intercolour Finland team were conducted to complement the information acquired by the thematic analysis. The interviewees' professional views give an understanding of the nature and status of wellbeing in forecasts, while the forecasts offer concrete information on how wellbeing and colours connect with each other on a verbal and visual level.

The thematic analysis was conducted in two parts. In the first stage of the analysis, the data was classified based on keywords found in each theme in order to find recurring topics. The theme descriptions were summarized to one or two keywords or phrases to capture the main idea of the theme. The second stage of the analysis focused only on the forecasts that included wellbeing as one of the topics to create a classification of types of wellbeing. Key words in the forecasts are words used in the official definitions of above mentioned institutes as well as their synonyms.

In the data, there were 312 shades of colour and 127 keywords related to wellbeing. The colours were classified in three ways; according to theme and according the main characteristics of colour; hue, saturation and lightness (Biggam, 2012: 3-4). Classification was done with the help of the NCS Natural Colour System. Each swatch from the forecasts were matched with the closest corresponding NCS colour. All samples were evaluated under natural light in conditions that were as little as possible susceptible to variation.

First, colour samples were classified into 5 groups based on the five themes of different type of wellbeing defined by the thematic analysis.

Second, the colours were sorted into groups based on the lightness and saturation. Four colour groups were formulated, light (L), dark (D), bright (B), muted (M) with the following formulas based on NCS values: Black value > 70 = D; Black value < 20 + saturation < 40 = L; Black value 5 - 65 + (black – saturation) > 40 = B; Black value 5 - 65 + (black – saturation) < 35 = M.

Third, colours were classified into 8 colour groups based on hue; values between Y90R- R20B = Red (R), R30B-R60B = Purple (P), R70B-B50G = Blue (B), B60G-G80Y = Green (G), G90Y-Y30R = Yellow (Y), Y40R-Y80R = Orange (O), Y10R-Y80R + black value > 30 = Brown (Bo), N-values and saturation value 02+R/G/B/Y/50R/50G/50B/50Y = Grey (Ge).

RESULTS AND DISCUSSION

The first stage of the thematic analysis revealed that wellbeing is one of the six main themes that appear in the forecasts. The theme of wellbeing can be further divided into five subthemes; mental, physical, social and hedonistic wellbeing and lifestyle (Figure 1). The themes are partly overlapping and complementing each other, but still distinguishable as separate categories.

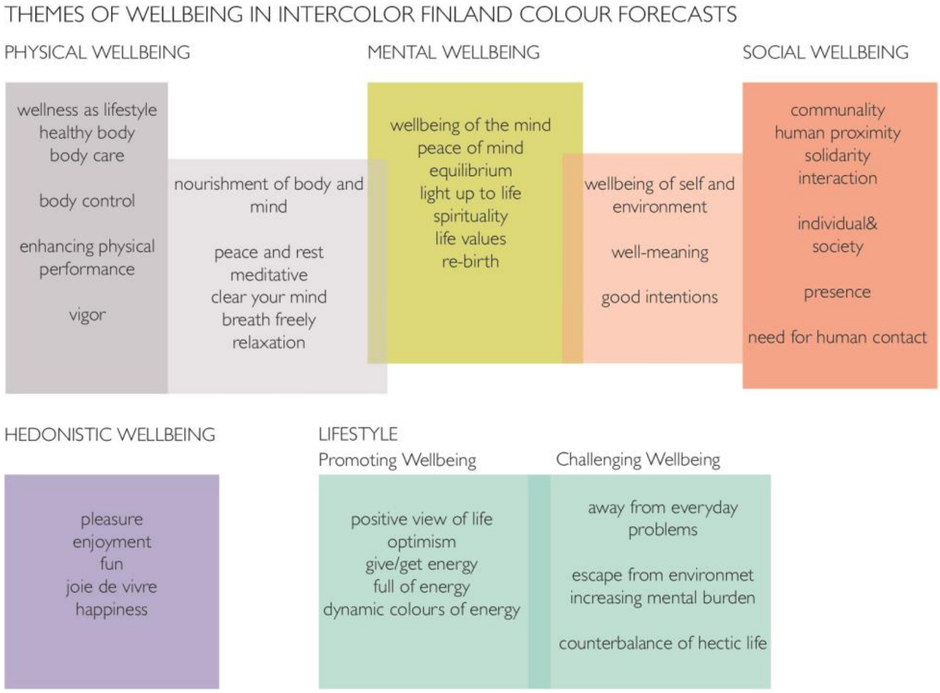

Figure 1

Figure2

The largest group categorized by hue (Figure 2) was greens (54 swatches) while the smallest groups was purples (26 swatches). Categorization according lightness and saturation (Figure 3) showed that light colours (112) were clearly the largest group, while dark colours (54) were the smallest. Categorizing colours by subtheme did not give explicit results (Figure 4). The figure shows that mostly light colours were related with mental wellbeing, while hedonistic wellbeing was characterized primarily by pure colours. Other subthemes were a mixture of several colour types.

Figure 3

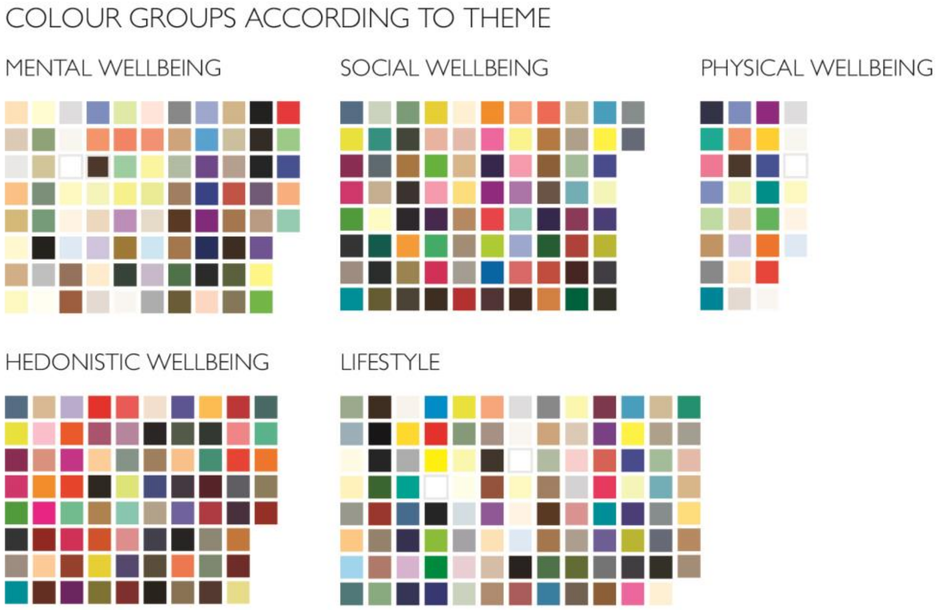

Figure 4

These findings refer to that the colour most often experienced to represent wellbeing, and particularly mental wellbeing, is a shade of light green. The results also imply that more important than hue, is the lightness of a colour when linking to wellbeing. These results can partly be explained by cultural influence. For example, green as the colour of nature is often connected with relaxation and harmony in Finland where people have a close relationship with nature, which is why it is understandable to connect it with wellbeing. Yellow was the second smallest colour group and it is also the least preferred colour in studies of western colour preferences. But as we know from previous research, people don't see colours the same way nor do they experience wellbeing the same way. So there does not exist a colour that represents wellbeing universally, and the variety of colours in the results of this study confirms that.

The results help understanding the connection of colours and words and how these associations create meanings and conceptions. This contributes to the vaster discussion on how to promote wellbeing of individuals through the use of colour at an objective level. The results can be implemented to different areas of design, such as interior and graphic design, for example in the fields of health care, public spaces and urban planning.

CONCLUSION

Wellbeing is a vast and multifaceted theme in the Intercolor Finland colour forecasts. Words and colours don't have a unambiguous connection, though there are certain noticeable tendencies. Light colours are most often associated with wellbeing. Lightness is more relevant than hue when connecting colours to the concept wellbeing. This diversity of colours and words and lack of a simple equations mean that both wellbeing and colours are a complex topic that cannot be forced under strict categories.

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Colour and therapies in TEACCH and Snoezelen rooms

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ABSTRACT
How colour is used in TEACCH rooms versus Snoezelen rooms. The underlying research was driven by the following questions: How can colour, introduced in games, equipment, objects, images and projections, be used as a teaching tool in a TEACCH room, as opposed to a Snoezelen room? How does a therapist work on specific skills with autistic children in a structured therapy environment such as TEACCH, in comparison to a non-directive therapy environment such as Soezelen?
The methodology adopted for the study is based on literature review, combined with observation in TEACCH and Snoezelen rooms; interviews to therapists from different areas, and analysis of the equipment used in each room.
Research results indicate that colour is used in diverse ways in both environments, being one of the major differences the way in which it is introduced to the children, as well as the use of light in connection with the equipment.

Keywords: *Colour, TEACCH, Snoezelen, Autism, Design for health.*

INTRODUCTION

As a part of an investigation about the design of therapy rooms in schools, we felt the need to understand how different therapy rooms work, regarding the activity intended.

We have selected TEACCH and Snoezelen therapy rooms for their characteristics regarding methodology used, being TEACCH a structured teaching space and Snoezelen a multi-sensory space with a non-directive approach. Furthermore, for allowing a wide range of therapies to be performed in both spaces, for example, speech, physical, psychomotricity, and occupational therapy, etc.

We have compared the use of colour in both physical spaces, as well as how colour is worked by therapists with the participants.

Different approaches to therapies were selected, to determine how their differences affected the manners in which therapists work with autistic children.

A brief description is presented about the components of both therapies, such as room characteristics, work systems, colours used in rooms, and how therapists present colour in equipment and exercises to the children during experimenting sessions.

We then compared the results about how therapists use the rooms, and how colour is used in each therapy and space.

The methodology used for this paper was a research-based on mix literacy reviews, TEACCH and Snoezelen rooms observation and interviews to 12 therapists in different areas of practice, such as speech, physical, music, occupational therapists, clinical psychologist, among others. Having them all previous experience in either Snoezelen or TEACCH therapy rooms.

We have gathered information about the similarities and differences in the use of colour for both therapy rooms, equipment and exercises.

In this study we have focused our attention in Autism Spectrum Disorder.

Although neither rooms are exclusive to autistic people, this group are one of the most beneficial to execute therapies, or different activities in such spaces.

THEORY

According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-V, 2013) Autism Spectrum Disorders shows difficulties regarding 3 different areas of development: communication, social interaction and behavior. Depending on the severity of the case, some people can show different degrees of ability or handicaps when it comes to performing any activity.

TEACCH (Treatment and Education of Autistic and Related Communications Handicapped Children) is a structured teaching methodology, developed by Eric Schopler and collaborators, in the 70's, in North Carolina, United States of America (Mesibov, She and Schopler, 2004).

"TEACCH is an evidence-based service, training, and research program for individuals of all ages and skill levels with autism spectrum disorders." (Lal, Shahane, 2011, p.170).

This methodology works in structured spaces, with individual's necessities, according to the severity of the disorder, helping teachers and parents to increase the child capacities exploring the strengths in autistic children: visual processing, memorizing routines and special interests (Lima, 2012).

TEACCH rooms are divided into 7 different sections (with visible boundaries and clear areas): meeting, transition, learning, working, play, computer and group work areas. In each area the participant is invited to perform exercises individually, or in group, with or without the therapists help, depending on the exercise, as this methodology aims for participant's independence and autonomy. The user follows a schedule where all the activities are represented with images, generally using PECS (Pictures Exchange Communication System). The user should respect the order presented in the schedule, executing one activity at a time, finishing the activity before moving on to the next one.

Snoezelen is a non-directive approach therapy, developed by Hulsegge and Verheul, in Netherlands, in the 70's, while working with severely disabled people. This therapy relies on the stimulation of the sensorial 'department', working with different senses, the most commonly visual, tactile, auditory, olfactory, gustatory, and also vestibular (working on the balance of the user) and proprioceptive (that represents how the person engages with the surroundings and the knowledge one has of the strength needed to execute some activity). Not only does this provide the stimulation of the persons senses, but also allows the person to experience it in a safe, attractive and comfortable environment, Fowler (2006).

Snoezelen is a process of "controlled sensory stimulation in a non-threatening secure environment involving all sensory systems. (…) commonly utilized for individuals with severe sensory impairments, autism, severe development and/or learning disabilities, etc." (Hotz, et al., 2006, p. 880).

Snoezelen rooms are spaces prepared for the person to relax, work different senses, explore, and execute some exercises, but not having to follow orders, or routines. The therapist remains in the room during the session, suggesting activities based on a plan previously decided for the participants needs, although the participant has the power to cease the activity at will.

Snoezelen also differs from TEACCH for not using white 'natural' light during sessions, regardless the therapy applied (a wide range of therapies can be executed in a snoezelen room, as in a TEACCH room, such as speech, physical, psychomotor, occupational therapies, etc.).

In Snoezelen room the visual stimulus is worked with different equipment that uses light and colour to illuminate the space. Some of this equipment also work with sound, movement, different temperatures, and other stimuli that allow the user to perform exercises and stimulate different senses at the same time.

EXPERIMENTAL: COLOUR IN THERAPIES – TEACCH AND SNOEZELEN

> "Colour is an international language through which people can share their emotions in an intuitive manner that may be nonverbal but is nonetheless widely understood." (Cretien Van Campen, 2011, p. 213)

This is extremely important for people like autists who may have trouble to communicate. By choosing a colour, they are communicating their preference, or implying understanding the purpose of the exercise.

We can also find colour both in physical space (regarding both therapies) as in material or equipment used to perform the exercises in such therapies.

TEACCH rooms do not often use highly pattern or overly bright colours as a palette choice for walls, ceilings and floors, as their effort is to keep the participant engaged and focused on the activity. In the rooms observed, we found the use of neutral or light colours, such as white, beige, light green, light blue and light pink, for walls, having some of the spaces divided into 'booths' where participants execute their activities, avoiding visual contact with other participants, as exemplified in figure 1.

Figure 1: TEACCH room, in school EB1/JI Senhora das Oliveiras, Darque, Portugal.

Figure 2: Routine Schedule, with user's photos.

Other colours are mostly applied to schedule boards created for the students to learn their routines, some materials the students use in exercises and in some equipment, such as tables, chairs, pillows, etc. The students are invited to participate in the colour choice of their preference for routine schedules, figure 2. Fiona de Vos (2011) mentions the importance of the participation of target groups in colour choice, for example, to understand their preferences and engaging them in the activity.

Snoezelen usually presents three different colour schemes: White rooms, Black rooms and Stimulating / Activity rooms (colorful room). White rooms were the most commonly used, although it has been reassured not to be a good choice, as it resembles hospital facilities. (Fowler, 2008; Mahnke and Mahnke, 1993). The rooms we have observed were painted in beige colour, or light blue colour, one with black ceiling (to visually lower the ceiling), and brown floors.

Both rooms use light, TEACCH uses white natural light, or artificial lights to illuminate rooms, as for Snoezelen it uses coloured light, which is a very important asset for this therapy. It uses 8 different colours: white, yellow, red, orange, green, blue, violet and pink to illuminate some equipment such as optical fibers, lighted water columns, wall panels, etc. Colour is presented through visual stimulus in the equipment previously mentioned, as well as through auditory stimuli. The user and the therapist can change all the colours in the room individually or together, creating different environments, as shown in figure 3.

Figure 3: Forbrain Snoezelen room, with lid optical fibers, water column, and wall panel.

Figure 4: Examples of TEACCH exercises using

TEACCH therapy produces a wide range of exercises using colours to teach how to differentiate colours, shapes, objects, as shown above in figure 4, images (PECS), letters, numbers, etc., to teach cause and effect, or rules (ex. Red to stop, green to go), as part as cognitive teaching (Lima, 2012). Autist people have better results when using visual aids, such as instructions or images. Colour is used as a tool, even when the main goal is not to learn about a specific colour.

Snoezelen therapy also uses colour as a ‘tool’ regarding attention seeking, to teach cause and effect, to work on synaesthesia (mixture of different senses, example, visual and olfactory). Although the coloured lights presented in the room are limited to 8 colours, they also work with projectors which can exhibit any image, offering a different range of colours depending on the user’s preferences and the aim of the exercise.

RESULTS AND DISCUSSION

Colours are used in both therapies as tools, helping aids, teaching material and comfort seeking for participants and therapists. The main differences found in both TEACCH and Snoezelen rooms is the use of coloured light in opposition to the use of white light, as well as printed images instead of projected images. Despite Snoezelen not using white light during therapeutic session it can be introduced to help participant feel comfortable entering the room, for example.

Colour in Snoezelen	Observation	Colour in TEACCH	Observation
Colour applied to room	Neutral, soft, non-intrusive	Colour applied to room	Neutral, soft, non-intrusive
Purpose of colour in the room	Comfort, safe space	Purpose of colour in the room	Organize space, keep focus
Colour used with light	Optical fibers, water column, wall panels, etc.	Colour used with light	Not observed
Colour applied to material	Mattresses, balls, bed, pillows, images, etc.	Colour applied to material	Chairs, balls, exercise materials, schedules, etc.
Light in the room	Coloured light in equiment, leds, optical fibers	Light in the room	White (natural) light and artificial light
Colour in exercises	Seek attention, teach about colours, work body movement, differentiate objects, etc.	Colour in exercises	Cognitive learning, teach about colours differences, shapes, sizes, images (PECS), numbers, words, objects, etc.
Exercise presentation with colour	Colour and images projection, objects, equipment.	Exercise presentation with colour	Printed images, games, objects, materials.

Table 5: Similarities and differences observed in therapy rooms and equipment

When inquired about colours in the physical space, the therapists were unanimous in identifying neutral or light colours on the walls as non-intrusive to maintain the focus on the activity and as creating comfortable and safe environments. Also, Miller (1997) confirms designers can manipulate colours in the environment to influence users' comfort and wellbeing. Referring to neutral and soft colours as a popular choice for rooms where it is intended to keep the focus on the activity and interaction occurring, more than in the surroundings. In such spaces such as Snoezelen and TEACCH, where the variety of stimuli is overpowering, the preferable choice for the physical space would be a neutral or soft colour as those on the spaces observed.

As for the colours applied to materials and equipment those were identified as helping tools, even though therapists mentioned not working on colour exercises exclusively, but that colour is a great help to differentiate images and objects, for example.

CONCLUSION

We can conclude that colour is used as teaching, learning and experimenting tool for autistic children in such environments. Either by using games, objects, images (PECS), projection, and other visual tools, therapists are able to communicate and work on different skills with autistic children using colour as a support, in both rooms.

Coloured light can transform the Snoezelen room in one big ‘tool’, as the user can interact with the entire surroundings, changing them at will. Colour helps the therapist to get the participant engaged in the activity, to create different environments, stimulating short- and long- term memory, for example. TEACCH being a structured space, uses colour to organize and divide the different areas, but also to promote interaction with the users through objects, materials, exercises, much more than the room itself. Hence, both therapies work with colour as a tool, but adopt different strategies.

The colour choices for the physical space rely on neutral and soft colours, non-intrusive, avoiding complex patterns, not to create distraction, in particular in TEACCH rooms, where participants are often concentrated in completing tasks.

Colour studies in therapy spaces are initiating, we recommend further investigation, in order to use colour at its best, to benefit therapeutic spaces, and those who depend on them.

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Forbrain Snoezelen Room.

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European Research Group on Light and Colour in Architecture for the care and well-being of older people

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ABSTRACT

The purpose of the content of this communication is to present the objectives and motives that prompt the need to establish the collaboration between diverse research groups of different European countries on light and colour in architecture for the care and well-being of older people. This grouping appears as an initiative to study and to offer a response to the progressive ageing of the population phenomenon. As experts in color and light in the built environment, this grouping intends to establish the guidelines for the chromatic characterization of the different types of architectural spaces targeted to older people, in a global way, for the different European countries, which will enable to achieve a specifically adapted habitability to their physical, sensory and psychological satisfaction needs.

Keywords: *older people, colour, built environment, visual comfort, European Network*

INTRODUCTION

At present, the increase of population age is one of the most evident realities in human development (UNFPA & International 2012). It is expected that this trend continues over the next decades (Eurostat & European Commission 2011). The fact that in the latter years the number of older people has increased implies a major shift in human evolution and, consequently, the challenges of older people needs must be faced. At the same time, diverse studies demonstrate that during ageing new answers are generated to the immediate environment (Caramelo Gomes

& Lott Daré 2011). These are gradual changes in most cases and profound changes in others; both have to do with the progressive decrease of the physical and perceptive abilities (Causapie et al. 2011; Sancho et al. 2002; Fu et al. 2009), and with the less adaptability to changes and spatial situations (Andersson 2011).

As it is known, physical environment can affect the well-being and behaviour of people. For this reason, the effect that physical space has on people is an issue of increasing interest in research related to the well-being of people. In particular, the effects of physical environment are of particular significance in care and health centres such as nursing homes (Falk et al. 2009), where residents, in the final stages of the life, are particularly vulnerable and can experiment a relatively high degree of uncertainty, disorientation and frustration in these places that happen to be their homes (Head & Isom 2010). Therefore, it is important to obtain the keys that enable the understanding of the importance of adapting the built environment to the specific needs of residents regarding visual comfort, promoting independence, orientation and, therefore, wellness.

Collaboration between different European countries is necessary to face the current situation from an overall view, whilst extending the knowledge of this field of study. In addition, by joining the diverse studies carried out by the different countries in a common and communal form it is possible to obtain a scientific justification which provides reasoned guidelines about how colour or chromatic environments and the lighting can influence in residential spaces for older people.

From this experience, we analysed the implications involved in a research of such characteristics at European level, of the same field of study, but from diverse perspectives, and evaluated their different impact levels.

METHODOLOGY

It is expected that this study focusses on theoretical and practical research. The work process involves carrying out forums, conferences and meetings where debates can be developed, as well as organising the necessary tasks in order to draw practical results and conclusions. The starting point of this work process raises the issue of different exchange possibilities of cultural nature other than just theoretical and practical research. In this sense, we deepen in the country's culture and adapt it to each case, at the same time as we get to know the cultural context of each place. The accorded aspects that in some way originated the early stages of work of this collaboration were the following:

With regard to the joint collaboration:

- To establish the interdisciplinary work patterns in the frame of the European Colour and Light Network.
- To analyse the difficulties and possibilities that an interdisciplinary research between different European countries offers.
- To determine the new perspectives and strategies resulting from the collaboration between different research groups and institutions in solving practical problems for their future application by professionals.
- To generate an European forum to which other countries can join in.

With regard to the common aims:

- To get to know the culture of each place.
- To determine the type of spaces we want to enhance and the characteristics of each of them.

- To improve the environment by improving visual comfort and the well-being of older people with the correct use of light and colour.
- To reach objective conclusions about the influence of colour in architecture, so that it can be effectively implemented in other European countries.

In order to assess the scientific impact of this European Colour and Light Network and evaluate its characteristics, an analysis should be carried out considering the possible weaknesses, threats, strengths and opportunities. Without being exhaustive, we will review the main characteristics that the creation of this new European collaboration raises.

RESULTS AND DISCUSSION

SIGNIFICANCE OF COLLABORATION BETWEEN EUROPEAN COUNTRIES

Many countries are facing the progressive ageing of population and the necessity of creating places for the well-being of older people. Collaboration between countries is an effective tool to extend, share and accelerate research in this field of study. For this reason, it is necessary to develop, adapt, transfer and share knowledge and personal experiences so that they can be extrapolated to all partner countries, while taking advantage of the existing resources and capacities. As a result, problems and concerns encountered beyond national borders can be solved, knowledge and resources can be widely shared and strategic collaboration to reach common goals can be promoted; offering beneficial solutions to all member countries.

SIGNIFICANCE OF A MULTIDISCIPLINARY APPROACH

The need to establish this multidisciplinary collaboration beyond the national level, is mainly due to the innovation processes and the evolution of the practice itself from a multiple point of view: the approximation between different areas of study to generate general knowledge of the research topic. This multidisciplinary collaboration consists of experienced architects specialised in colour in architecture on the one hand and experts in the field of health on the other hand; two very different professional areas that are closely related at the same time, since the definition of architectural spaces that promote the health and the well-being of older people is pursued. In other words, places that contribute to internal organisation from a technical point of view and that look for the stay and comfort of the users, the proper development of the welfare processes and the optimization of human and material resources. Therefore, this reality requires a methodological collaboration of diverse and different disciplines and, in general, the collaboration of specialists from different areas of knowledge so that the object of study can be understood in a comprehensive manner.

STRATEGIES TO OBTAIN RESULTS AND FOR RESULTS DISSEMINATION

The projects that are currently carried out by the different research groups are the following ones:
- SPAIN. Spain is developing a State Project funded by the Ministry of the Economy, Industry and Competitiveness and the State Research Agency on *Modifications of Visual Comfort in Residential Centres for the Improvement of Quality of Older People*. This project is being carried out by a multidisciplinary group of researchers that consists of architects of the Universitat Politècncia of València, sociologists and psychologists of the Universitat of Valencia, as well as other professionals.

This research aims to establish the guidelines for the chromatic characterization of indoor spaces for older people, taking into account the existence of different rooms where different activities are held. By working with light and colour we are able to improve the existing facilities by adapting them to usage and visual comfort.

Figure 1: Upper row: Example of public nursing homes' typical corridors in Spain. It is noticeable the presence of dazzles as well as very dark zones. White-coloured spaces with no interest nor stimulus too. Bottom row: Example of chromatic scenes in public nursing homes in Spain. The colours used do not meet any specific design criterion.

- SWEDEN. Sweden is seeking to deliver further light on the importance of an adapted environment for older people in sheltered as well as ordinary housing, in relation to adequate and supportive colour and light. The work is conducted in a multidisciplinary research group, situated at Gotheburg University within Caring Sciences together with researchers fråm Center for Health Care architecture at Chalmers University. The goal is to provide evidence based facts for guide lines on adequate colour scheemes and illumination in older peoples environment in order to support safety and well-being.

- NORWAY. Norway has initiated different studies and pilot projects within research programs, especially at The University of Bergen and The University of Trondheim (NTNU). Two of these pilots are being presented at the AIC meeting in Lisboa; "Saturated Space. Colour schemes for elderly in Nursing Homes."(Mette L´orange UiB).

More specifically, this initiative is discussing how the use of saturated colours can improve the environment of nursing homes, and how it affects the behaviour of dwellers and employees. Colour makes a vital tool in establishing safe, explanatory and stimulating environments, especially for people with cognitive setbacks. Qualitative data collection methods are used for evaluation, group discussions, individual interviews and observations.

Figure 2: Left: Existing situation for many nursing homes in Norway. Middle and right: New colour schemes (UiB).

By bringing together the results obtained from the different researches performed we attempt to consolidate multidisciplinary collaboration in the field of the well-being of older people studies. As a result, we manage to establish the proper knowledge and experiences of the topic of research from a global perspective, based on research training, by firstly developing a conceptual theoretical framework from which starting the research. Thus, by gathering the results obtained in the different European countries we contribute to develop the knowledge of the perceptive characteristics of the different architectural spaces addressed to older people.

Therefore, there is the need of developing organizational strategies and resources to reach conclusions about the topic of study at the prospect of a comprehensive research. In this case, the goal is to be capable of analysing, defining and proposing chromatic scenes that foster practical solutions to the needs of residents, and that improve their living conditions and their personal well-being. As a result of the findings of the research, we intend to facilitate chromatic guidelines to architects and designers so that they can apply them in their projects and thereby develop a more habitable architecture. For that reason, it is necessary to spread the knowledge and to promote its use to improve the quality of life and visual comfort of the older people that live in nursing homes. It is equally important to make official organisms, private entities and general population aware of the current situation and of the importance of colour in the architectural space, so that specific actions can be taken for specific case studies.

CONCLUSION

In conclusion, the aim is to formalise this new European research group in the field of light and colour and to increase the number of member countries. In addition, we look forward to making progress on research and disseminating research information through seminars, conferences and scientific journals. Certainly, future scientific efforts based on evidence must have the potential to address the unique needs of institutions for older people. Therefore, we aim to strengthen European Colour and Light Network research taking into consideration the findings based on the relationship between colours of the chromatic scene in architecture and its proper design to improve the visual comfort of older people. To do so, new reasoned colour schemes that can reduce the negative consequences of age-related eye disorders must be explored.

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Visual Images as Visual Information Units

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ABSTRACT

When we talk about vision and visual images, we always think in a global and continuous image, occupying our entire field of vision, without holes or gaps: a fully completed image, well defined and focused, in which all elements of the visual world are in a perfect state of geometric definition, all the distances between elements are perfectly defined and understood and where the laws of perspective fully work. However, visual images are made of visions but also of memories, so the question to answer is - "What are the pure visual images we see, just before the use of memory (that we could name "visual information unit") and what do they really look like?".

As our proposal is to present the kind of visual image that feeds vision, before visual memory is applied, we have to know where people are looking on when they observe spaces. Considering that we live in an architecture world, inhabiting cities and living in houses, this work was developed under the three-dimensional architectural environment, both indoor and outdoor, that we live in day by day. Architectural spaces were observed by different participants in order to get samples of visual information from those observations.

The process of compiling these images was done with the use of eye tracking technology. The images we as generated in video format and all the collected elements were transferred to a photographic support where fixations and saccadic eye movements were notated in order to make comparative analysis.

The collection of eye tracked visual data was completed by considering two different kind of approaches related to the visual scape: indoor and outdoor spaces (architectural spaces and urban spaces), and spaces whose design has been done under different rules of geometry: spaces ruled by orthogonal geometry and spaces ruled under non-orthogonal geometries.

By an analysis of the retina, made in order to know its composition related to the number of photo-sensitive cells, its features and its distribution, allows us to determine the development of image definition at the eye and, therefore, to construct a sample of a Visual Information Unit to be presented as the result of this work.

The merging process of data, to build the image-synthesis, was constructed, from the video support to the photographic support, frame by frame and dot by dot. Using a cad software to draw the lines and dots, and a photographic production software to edit the image-synthesis, all the work is a whole handmade graphic design construction.

In conclusion, we present two final images that will show how we see the visual world around, allowing us to better understand the significance of memory when completing the blank spaces of the visual image - creating the elements of visual world that we never saw.

Keywords: *Eye movements, Fixations, Retina, Image, Eye tracking*

Image 01 - Visual landscape as we remember.

INTRODUCTION

This work has been developed by the pressure of curiosity to understand what are the images that your eyes really see when we observe a three-dimensional space. “Vision doesn’t occurs in the eyes. It occurs in the brain.”[1] as we all know since a long time ago, but what kind of physical event happens in the retina to produce vision? If memories constitute part of the visual images that we see, what portion do they occupy?

Eyes move around the visual world not randomly but in a disorderly way, in order to find visual elements to see. From those elements they pick visual information to build visual images. Vision events are fixations but also saccadic eye movements of different amplitudes. During the saccadic eye movements, eyes cannot see[2], so they only see in fixations. What portion of fixations do we have in the process of vision? What kind of image do this look like ?

This is the purpose of this work.

THE MAIN IDEA

Four spaces in Lisbon were found to be visually analysed by 30 different observers. This methodology was developed under eye tracking technology recording system, in order to get samples to analyse those visual events from observations, fixations, saccadic eye movements, and other events, to understand their shape and consistency. These events were transferred, from video support to a bidimensional photographic support, in order to have similar samples to make comparative analysis. We got 120 videos of 20 s. each, which means 60 000 frames to analyse.

1 Ramachandran, V.S. The tell-tale brain, Windmill Books, London, 2012, p.41.

2 Yarbus, A.L. Eye movements and vision, Plenum Press, New York, 1967.

The immersion of the viewer in the 3D architectural space was an imperative, to consider the time spent in the depth visualization. Then, the eye tracking technology to be used should be a portable one. That would allow, too, the natural movements of the observer during the space observation.

The collection of eye tracked visual data was completed considering two different kind of approaches related to the analysed visual space: indoor and outdoor spaces (architectural and urban spaces), and spaces whose design has been done under two different paradigms of architecture: the paradigm of order and the paradigm of processes - architecture designed in a close relation to orthogonal geometric thinking, and architecture made by other different rules, related to organic and natural characteristics of the place.

THE PLACES

The four chosen places were all located in Lisbon and, as detailed above, two of them were indoors and the other two were outdoors. This selection was crossed with two cases of architecture ruled by orthogonal geometry, and other two ruled by a non-orthogonal geometry.

The two cases of regular geometry composition were a church – Church of S. Domingos – as an indoor space, and Terreiro do Paço, (Lisbon's main riverside square) as an outdoor space. The two places of non-orthogonal geometry composition were the atrium of a commercial centre – Alvaláxia – as indoor space, and an irregular square in Alfama – Largo de S. Miguel – as an outdoors.

This cross-grid of the places' characteristics, allow to develop other comparative analysis, not included in this work.

THE COLLECTING PROCESS

All the four places were object of observation by all 30 different observers, positioned always in the same specific spot, wearing a portable eye-tracker, to determine where are they looking and what are they looking at. Each observation, concerns the space around the participant and took exactly 20 s., representing 500 frames per video to analyse.

A panoramic photography of each space was made from the same place used by the observers in their work. This panoramic image contains all the visual elements existing in the visual world, in front of, and seen by all the observers, allowing the possibility to translate the video information to this photographic support. Each panoramic photography with the visual information of an observer was worked on a cad software and constitutes a sample of each specific observation.

The visual elements displayed in the photographic sample will show different kinds of events, as fixations, the length of saccadics, the shape of eye-movements and other events during that specific observation of the space. It is possible to identify all the fixations, all the saccadic eye movements, distinguish its amplitudes and time of duration. It was also possible to detect some kind of fixations that were not detected[3] by the eye tracking system because the head moves during the observation but, those fixations really exist due to VOR[4] - Vestibular Ocular Reflex[5].

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[3] The eye tracker usualy has a reference system on the surface of the glasses and detects all the eye movements related to that reference system in their coordinates x;y. Because with the natural movements of the head and the body also moves the eye tracker reference system, the eyes can stay on a target during a fixation, but this fixation stays undetectable to the eye tracker.

[4] Vestibular Ocular Reflex is a reflex eye movement used to compensate the movements of the head and body, whose objective is to maintain the eye on the target.As a reflex it is not a conscientious movement.

[5] In fact, the amount of fixations due to VOR are 34,76% of all fixations and there are also multiple fixations with a VOR parcel which are 58,39% of all. - Alão, N. Reconstituição geométrica da visão, Lisbon School of Architecture, Lisbon, 2017

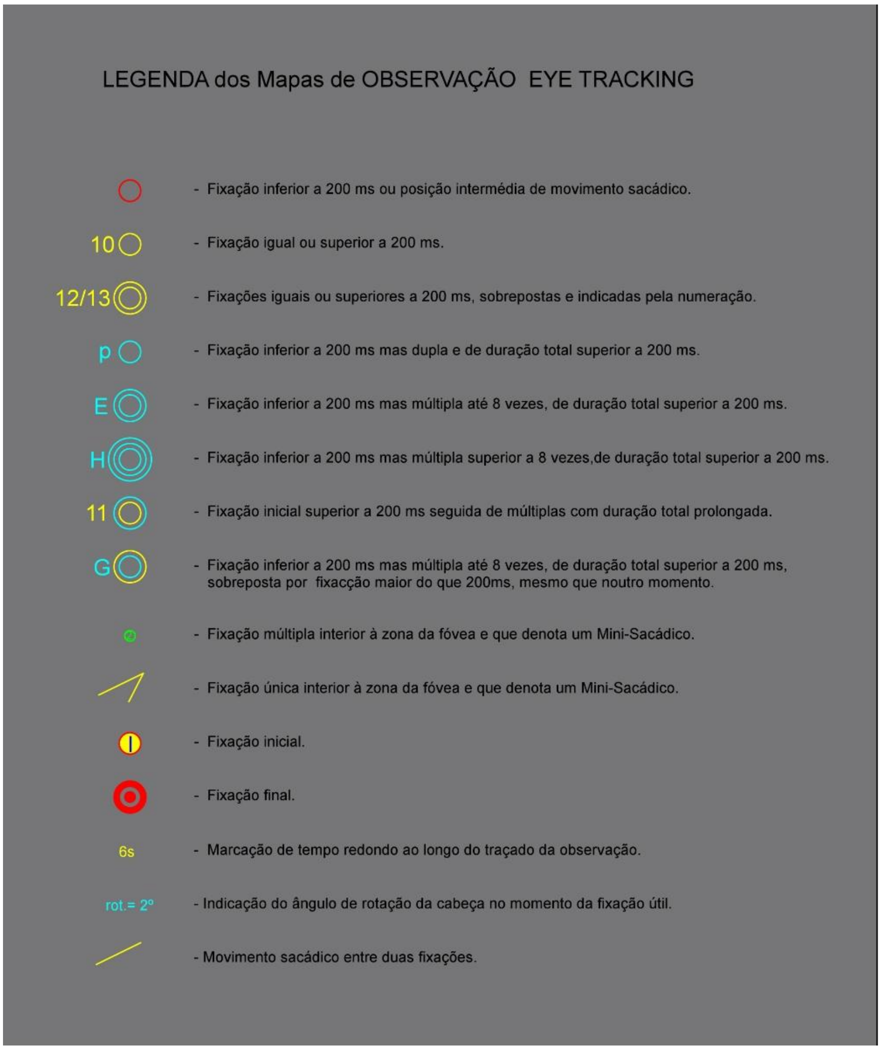

Image 02 - Reference guide of the all visual events detected.

THE PANORAMIC IMAGES

The panoramic photographic images, to constitute the bidimensional support of the samples, were made by a stitch image software, as a result of translation between spheric and planar visual perspectives.

As the result of this work, the two of four cases chosen to present are concerning the Alvalaxia Commercial Centre, an indoor case of non-orthogonal geometry, and Terreiro do Paço, an outdoor case of orthogonal geometry.

MERGING THE INFORMATION

The merging process is constructed frame by frame, dot by dot, from the video support to the photographic support using a cad software to draw the lines and dots whilst accessing data from the visual information generated by the eye tracking collection. Comparative analysis can now be made but our goal was to find the pure visual image as visual information units.

All the samples were drawn, with all the visual events detected on the collecting process. All the saccadics were annotated, as all the fixations in its different kinds, and even some of the rotation angles of the head. The time of certain fixations was also annotated, to identify the development of the observations.

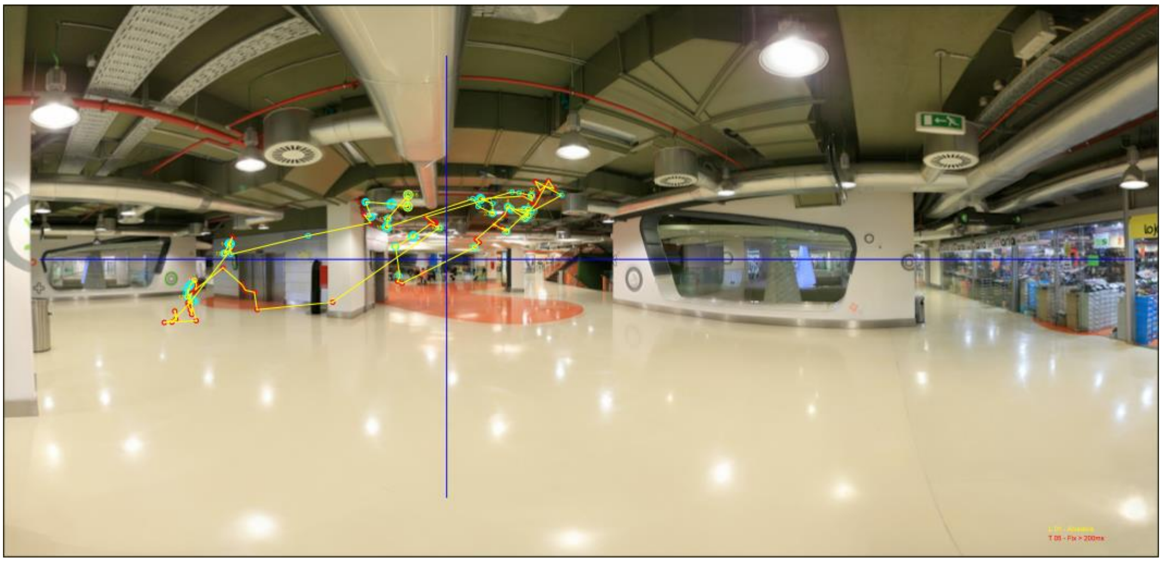

Image 03 - Example of a sample of the case “interior, non-orthogonal”.

It is now possible to identify in each sample, with precision, where all the fixation occurred and determine, with a study of the retina, what kind of different visual grades of definition do we have in the global image that we think to see. As we see above, all the saccadics are identified by a yellow line (independently of its amplitude), the red points are non-fixations and the blue and yellow points are the VOR fixations and stable fixations (bigger tnan 200 ms.). They are already represented by small circles, so they will adapt very well to our final image.

As we can see bellow, in the image 4, there are represented all of the fixations detected in all of the samples, in the case of study “interior, non-orthogonal” - atrium of Alvaláxia Comercial Centre. The main colour is blue, which means the greater amount of fixations are VOR.

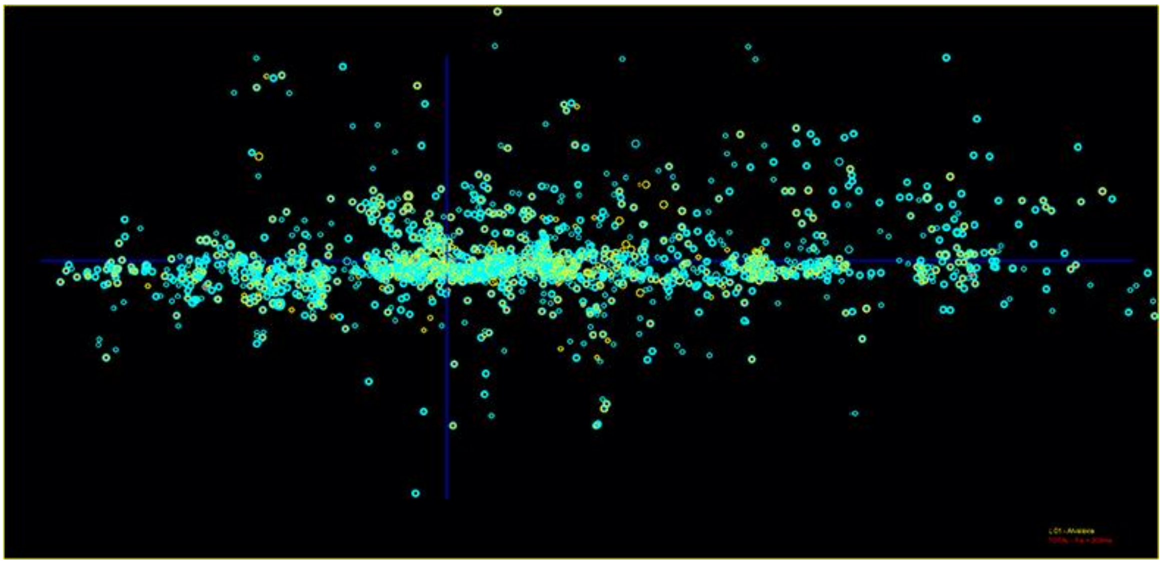

Image 04 - Sample with all the results of the case “interior, non-orthogonal”.

THE RETINA

The Retina is made from different areas with different densities of photo-sensitive cells and different kinds of cells and characteristics[6]. There are parts of the retina where these cells are together, one amongst the other, proportional to each kind, but in other parts, they don't mix.

An analysis of the retina was made in order to know its composition related to the number of photo-sensitive cells and its features. This knowledge allowed us to determine a possible range of definition features of the retina and an image definition at the eye and so to build a mask of the definition grades in relation to the centre of the retina.

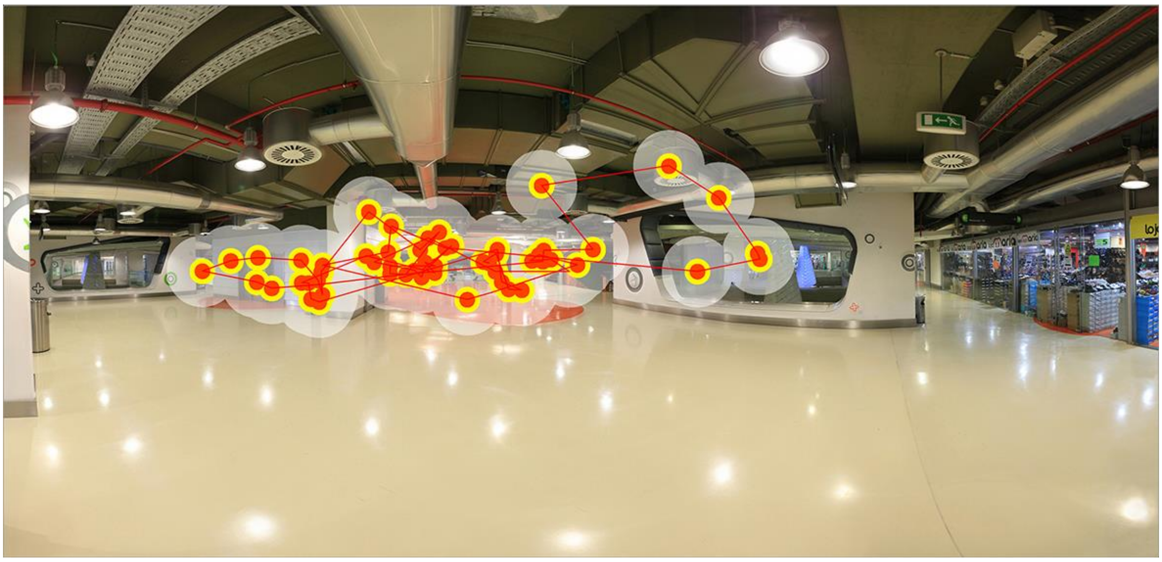

Image 05 - Example of a mask of the retina overlapping a sample, before post-production photo work.

A model of the retina was built in a cad software, then was built a mask of each of the samples and used in the post-production photographic work of the panoramic images, in a direct relation to the points of fixation detected in each sample.

Image 06 - Visual area of the landscape impressed on Fovea-excluded all other impressions in retina.

[6] Mackay, W.A. Neurofisiologia sem lágrimas, Fundação Calouste Gulbenkian, Lisboa, 2011, p.90;
Hogan, M.J., Alvarado, J.A., Weddell, J.E., Histology of the human eye: an atlas and text book, W.B. Saunder Company Publishers, Philadelphia, 1971

Different areas with different compositions of the retina were defined to allow the construction of the final image of the visual world as we think it is seen.

In the image above, we can understand the limits of our well defined visual perception, related to foveal vision. Out of this small area, images have a lack of detail and the colours start to be diluted. We have yet to consider the role of the attention - visual attention - which, eliminating some elements less interesting at the moment, reduces the field of vision to smaller details to see.

HOW DO WE BUILD THE VISUAL IMAGES

To those small points of visual world, detected and absorbed, we could call "visual information units": alone they don't give us too much visual capacity, but all together they contribute to build our visual image, at least in the portion we need to build an entire visual image, global and continuous, occupying our entire field of vision. The holes and gaps are filled with visual memories, mostly taken from earlier views, directly before or older.

Each point has different kinds of information as colour, lines of contrast, brights, shades, small angles and other kinds of small details. We see like this, piece by piece, joining one to another and building an whole visual image.

As we can see above, in image 5, the eye tracking line localize all the fixations where masks corresponding to different kind of retinal areas were positioned to define different kinds of visual definition, corresponding to blur and to colour saturation and brightness. Is to note that here the field of vision is wider than normal because it corresponds to all the space around the observer considering all his possible movements during the observation.

CONCLUSION

Due to the central vision, of great detail and definition, we can a have very sharp images of all the visual elements in the world around us, their details, colours, brights, shadows, lines of contrast and textures. This kind of visual images we only have in fovea. That's why the eye is always in movement, around all visual world, searching for information to formulate visual images.

In this process, the eyes travel around the visual world to pick some information from time to time, which leads to a uncontinuous visual image as result. Each of these small points of visual information, with some kind of visual elements to analyse, where visual attention excludes some of those seen elements to allow a better visual analysis of only one of them inside fovea, we call visual information unit.

The peripheral image, captured by peripheral areas of the retina around fovea, because of the characteristics and number of the photosensitive cells, are of less definition, less colour amount, less saturation, and can even be, at a certain point, unfocused. Nevertheless, these areas of less definition can give us some visual capacity, not a very detailed vision but global and blurred, enough for the brain to join several pieces of visual information, from all of the "visual information units", to build an entire image.

So, at this point we present two final images that will demonstrate how do we really see the visual world around us, allowing us to better understand the significance of memory to completing the blank spaces of the visual image - creating the elements of visual world that we never saw or, that we never saw correctly.

Image 08 - Visual image of a non-orthogonal indoor space, as we see it.

Image 09 - Visual image of a orthogonal urban space as we see it.

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Influence of the Number of Distractor Colours on Performance in the Visual Search Task Cued by S-cone Stimulus Value

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ABSTRACT

Katsura et al. (2016) examined visual search performance cued by S-cone stimulus value and showed an advantage of dichromacy. Here, we investigated the degree to which colour discrimination can explain their results. The colour of a target disk was different from that of other distractor disks only in terms of S-cone stimulus value. In a one-distractor-colour condition, we assumed the target detection time to be the colour discrimination property. In a two-distractor-colours condition, we replicated the experiment by Katsura et al. (2016) and compared the results with those in the one-distractor-colour condition. The S-cone stimulus value of the target colour was the mid-point of two distractor colours in the two-distractor-colours condition. The detection time was much shorter in the one-distractor- vs. two-distractor-colours condition. Our data suggest that visual search performance cued by S-cone stimulus value when two colours are assigned to distractors cannot be explained by colour discrimination.

Keywords: *dichromacy, visual search, S-cone stimulus value*

INTRODUCTION

Human colour vision is generally trichromatic and relies on L, M, and S cones. Some people lack one type of cone (dichromacy). The types of colour vision are classified into three groups, that is, protanopia, deuteranopia, and tritanopia, depending on the absence of the L, M, and S cones. Individuals with dichromacy are thought to have deficient colour perception because they cannot discriminate certain colours. Generally, trichromacy is thought to be superior to dichromacy. However, some studies have indicated that there may be some advantages of dichromacy. Morgan et al. (1992) reported that dichromats performed better than trichromats on a task that required observers to detect different oriented targets in red-green coloured objects. In the experiment, a red-green camouflaged pattern affected trichromats as a type of visual noise that impaired searching, but did not affect dichromats because they could not discriminate between the red and green Colours. Therefore, the experimental condition was particularly favorable to dichromats. Katsura et al. (2016) used a visual search paradigm cued by S-cone stimulus value in which both trichromats and dichromats could sufficiently perceive a target, although dichromats had an advantage. In the present study, we investigated whether a visual search paradigm based on colour discrimination could explain their results.

METHODS

Observers

Four trichromat, two protanope, and two deuteranope observers participated in the experiment.

Apparatus

Stimuli were presented on a CRT colour display (SONY HMD-H200). The resolution of the display was 1024 × 768 pixels with a refresh rate of 75 Hz. The display was placed at a distance of 53 cm from the observer.

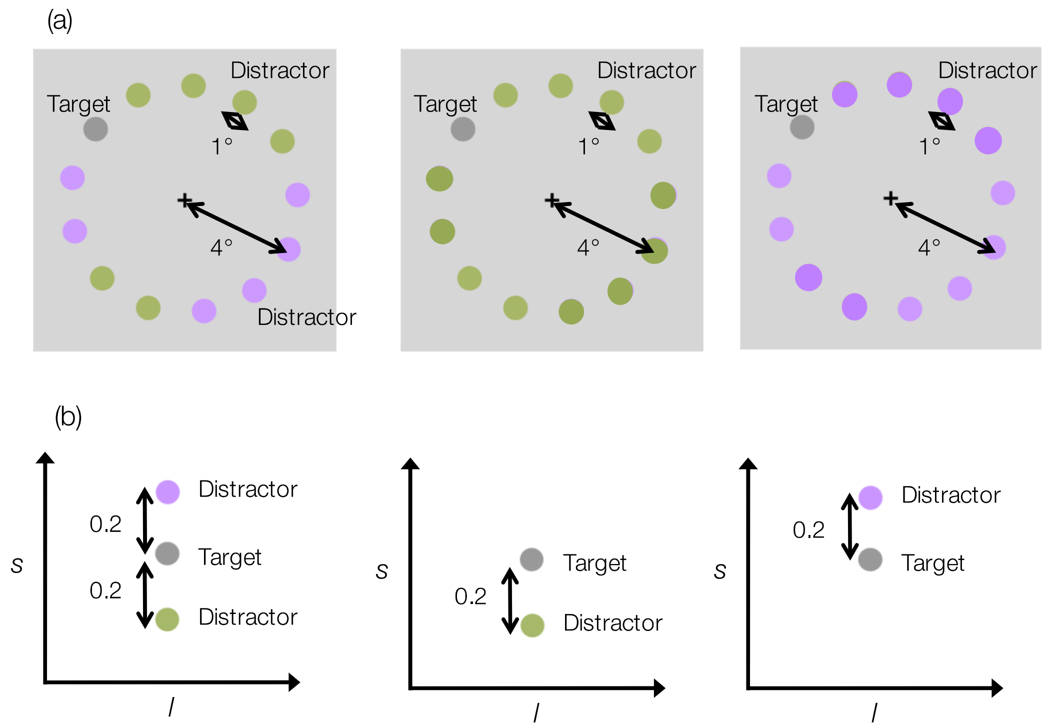

Figure 1: (a) Visual search stimuli used in the study. (b) Relationships between chromaticities of the target and the distractor(s).

Stimuli

Stimuli consisted of thirteen coloured disks presented on a grey background (D65 chromaticity, 15 cd/m^2) as shown in Figure 1 (a). The disks, which were 1 degree in diameter, were arranged at equal intervals on the circumference of a circle with a diameter of 8 degrees. One disk functioned as a target, and the other twelve were distractors. There were two distractor conditions: a one-distractor-colour condition and a two-distractor-colours condition. In the one-distractor-colour condition, one target colour was assigned to one of the disks and one distractor colour was assigned to the other twelve disks. In this condition, it is possible to examine the effect of colour discrimination property on detection time because the detection time depends on the colour difference between the target colour and the distractor colour in the visual search task. In the two-distractor-colours condition, we replicated the experiment by Katsura *et al.* (2016). The target colour and the distractor colours were only different in terms of S-cone stimulus value in both conditions. In addition, the S-cone value of the target colour was positioned between those of the distractors in the two-distractor-colours condition. The luminance of the disks was 10.2 cd/m^2, and the chromaticity was defined on an equal luminance plane in LMS colour space, as proposed by Stockman and Sharp (2000). The luminance (*Y*) and chromaticity coordinates (*l, s*) of the disks were described by the following equations:

$$\mathrm{Y} = 0.692\mathrm{L} + 0.349\mathrm{M} \qquad (1)$$

$$l = \frac{0.692L}{Y} \qquad (2)$$

$$s = \frac{S}{Y} \qquad (3)$$

The D65 chromaticity of the background was equal to (*l, s*) = (0.69, 0.5). The *l*-coordinates of the target (l_{tar}) were adjusted from 0.66 to 0.72 with an interval of 0.01. The *s*-coordinates of the target (s_{tar}) were 0.3, 0.5, and 0.7. The chromaticities of the distractors were different from that of the target in terms of the *s* value, such that the search cue was the S-cone stimulus value. The *s*-coordinates of the distractors (s_{dis}) ranged from +0.2 or -0.2 to s_{tar}. The stimulus duration was 13, 27, 53, 107, 200, 400, 800, or 1600 msec in the one-distractor-colour condition, and 27, 53, 107, 200, 400, 800, 1600, or 3200 msec in the two-distractor-colours condition.

Procedure

Each experimental session commenced after a 2-min dark adaptation period. The stimulus, shown in Figure 1, was presented. A random-dots pattern was displayed for 400 msec following the stimulus to mask colour afterimage. The display was occupied by a blank screen (background with a fixation point in the centre) after the masking. The observer's task was to indicate the quadrant in which the target disk was located. The response triggered the next stimulus. Each participant performed a total of 15120 trials. There were 21 target colour conditions, 8 stimulus duration conditions, and 3 distractor conditions (the two-distractor-colours condition and the one-distractor-colour conditions with s_{dis}=s_{tar}-0.2 and s_{dis}=s_{tar}+0.2), where each condition was repeated 30 times. One session contained 168 trials, and 90 sessions were performed. The 21 colour conditions, the 8 stimulus durations, and the 3 distractor conditions were randomly chosen in every trial.

RESULTS AND DISCUSSION

Figure 2 shows the relationships between the stimulus duration and correct response rates for each Colour vision type when s_{tar} was 0.5 in the two-distractor-Colours condition. The different symbols indicate the results of different l_{tar}s values. The different lines indicate Weibull Fitted curves for the data points. We found that the correct response rate increased as the stimulus duration increased for every Colour vision type. Protanope KS and deuteranope KY responded correctly in almost every trial at approximately 800 msec, whereas trichromat SK took more time to obtain correct responses with the exception of trials with $l_{tar} = 0.69$.

To further compare the visual search performance for each colour vision type, we calculated the duration thresholds for cases in which the correct response rate was 72.4% from the results of the fitted Weibull functions. Figure 3 shows the geometric mean of the duration threshold for each s_{tar}. The abscissa represents l_{tar}, and the ordinate represents the duration thresholds. The different symbols represent different colour vision types. The duration threshold for trichromats was substantially longer than that for dichromats. Specifically, l_{tar} was below 0.68 when s_{tar} was 0.3, l_{tar} was 0.66, 0.67, 0.71, or 0.72 when s_{tar} was 0.5, and l_{tar} was above 0.70 when s_{tar} was 0.7. Figures 2 and Figure 3 show that we were able to replicate the results of Katsura et al (2016). Namely, the detection time was shorter in dichromats than that for trichromats when the target and the distractors were reddish or greenish.

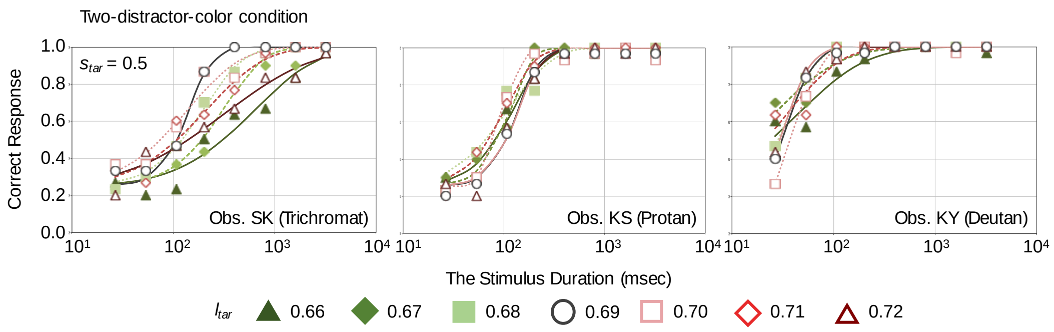

Figure 2: Relationship between correct response rate (s_{tar} = 0.5) and stimulus duration for each colour vision type.

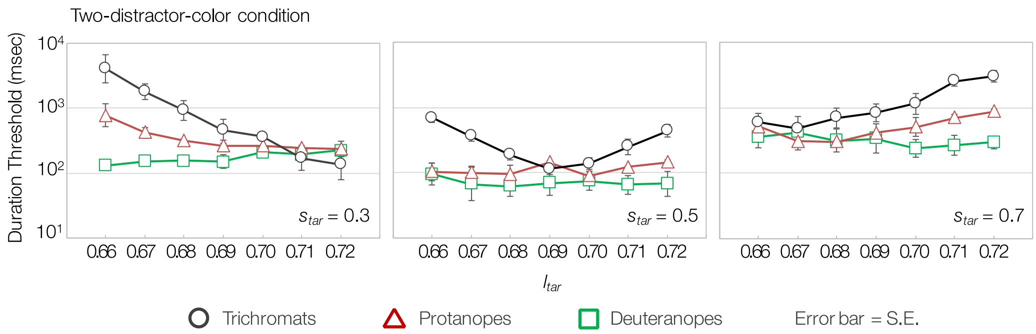

Figure 3: Comparison of duration thresholds between Colour vision types in the two-distractor-colours condition.

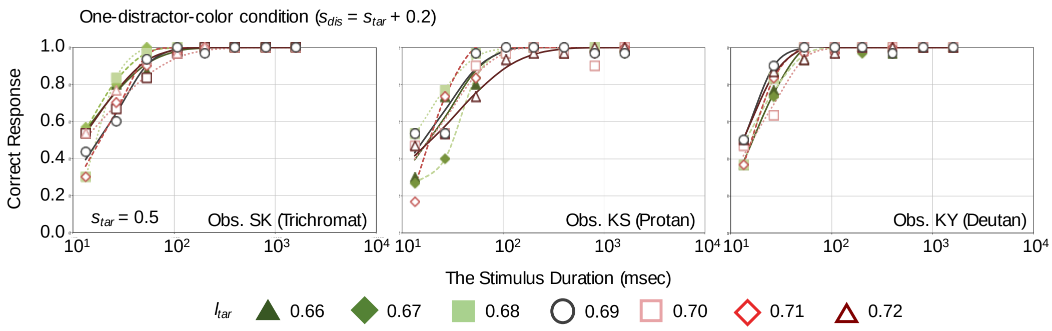

Figure 4: Rate of correct response (s_{tar} = 0.5) and duration time for each colour vision type in the one-distractor-colour condition.

Figure 4 shows the correct response rate as a function of the stimulus duration for each colour vision type when the s_{tar} was 0.5 in the one-distractor-colour condition. In this condition, the correct response rates were higher than those in the two-distractor-colours condition for every colour vision type, and the differences between trichromats and dichromats were small. These data suggest that the performance reported by Katsura et al. (2016) depends on the number of distractor colours.

Figure 5 shows the geometric means of the duration threshold for each colour vision type when the s_{tar} was 0.5. The symbols represent the different distractor-colour conditions. The duration thresholds were longer in the two-distractor-colours condition compared with those in the one-distractor-colour condition. In the one-distractor-colour conditions, the dependence of the duration thresholds on the l_{tar} was smaller in trichromats, and the difference between trichromats and dichromats was smaller. Similar tendencies were obtained when s_{tar} was 0.3 and 0.7. These results suggest that visual search performance cued by S-cone stimulus values when two colours were assigned to distractors could not be explained by simple colour discrimination property. Yokoi and Uchikawa (2005) reported an effect of colour category on detection time. Future work may include an investigation of our visual search performance results in terms of Colour appearance.

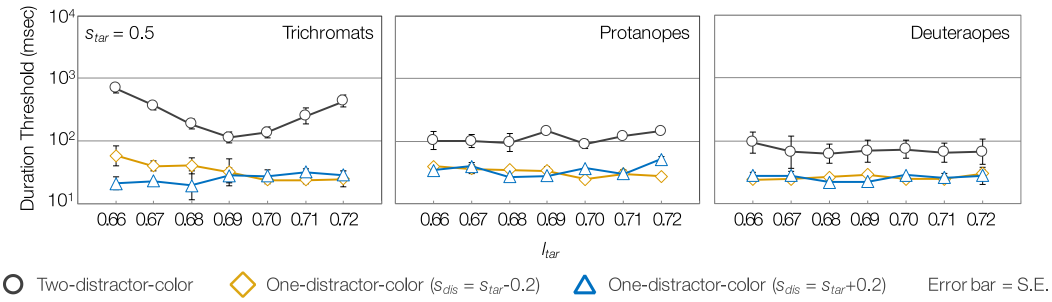

Figure 5: Duration thresholds (s_{tar} = 0.5) in the distractor conditions for each colour vision type.

CONCLUSION

In the present study, we investigated whether a visual search paradigm based on colour discrimination could explain the results of Katsura et al. (2016) in terms of the number of distractor colours. In the one-distractor-colour condition, the detection time for trichromats approached that for dichromats. Therefore, detection with two distractor colours cued by S-cone stimulus value, where the S-cone stimulus value of the target falls at the mid-point between the two distractors, cannot be explained by the colour discrimination property.

ACKNOWLEDGEMENT

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Categorical Colour Naming in Anomalous Trichromats for Colour Stimuli with Different Durations

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ABSTRACT

Montag (1994) examined the role of rods in deficient categorical colour perception. They suggested that, as opposed to rods, residual cone pigment affects categorical colour naming. We investigated differences in categorical colour naming between dichromats and anomalous trichromats to determine whether an anomalous cone (present in anomalous trichromats) contributes to categorical colour naming in the same way as a residual cone, as suggested in previous research. One protanomal, one deutanomal, one deuteranope, and two trichromat observers participated in the experiment. Observers viewed colour patches presented on a LCD monitor for different durations. The observer task was to assign one colour name out of 14 Colour names for each colour patch. The deutanomal observer exhibited categorical colour naming properties of both dichromat and trichromat observers. Moreover, the similarity in categorical colour perception in anomalous trichromat and trichromat observers depended on the lightness of the colour patches and the colour vision type.

Keywords: *Categorical colour naming, Anomalous trichromats, Dichromats, Trichromats, Duration time*

INTRODUCTION

Whereas trichromats have three types of retinal cone photoreceptors, dichromats only have two types. Despite lacking one type of photoreceptor, dichromats can distinguish colours using trichromat-like colour names (e.g. Montag and Boynton, 1987). Montag (1994) suggested that residual cone pigments rather than rods affect dichromat performance in the categorical colour-naming task. However, dichromats produced trichromat-like colour-name responses in long stimulus duration conditions only.

There is another type of colour vision called anomalous trichromacy. Like trichromats, anomalous trichromats have three types of cones, but the spectral sensitivity of one of the cone photoreceptors is shifted. Furthermore, the degree to which cone peak sensitivity is shifted varies among individuals (Neitz et al. 1999).

In this study, we investigated whether the behavior of anomalous cones in anomalous trichromats was similar to that of residual cones in dichromats in the categorical colour-naming task. In addition, we were curious about how colour-name responses corresponded with the amount of shift in peak cone sensitivity in anomalous trichromats. Therefore, we measured colour-name responses in anomalous trichromats using different stimulus durations.

METHOD

Apparatus and Stimulus

A colour patch was displayed on a 24-inch LCD monitor (EIZO ColourEdge CS2420-BK) controlled by a computer (Apple Mac mini) in a dark room. The viewing distance was 60 cm.

Figure 1 shows an example of the colour patches used in the experiment. The Colour patch was a 2°×2° square presented in the centre of the monitor. We chose 1017 colours from the Munsell Colour system. We calculated the chromaticity and luminance of the colour patches under the assumption that the luminance of the perfect diffuse white surface illuminated by the D65 light was 220 cd/m^2. Moreover, we used R, G, and B, which were the three primaries of the monitor, and C, M, and Y, which were combinations of the three primaries. The stimuli details are shown in Table 1. There were colour patches for a total of 1023 colours.

The background of the colour patch was a neutral grey (77.64 cd/m^2) comparable to N 6.5 with a white reference frame (193.05 cd/m^2).

There were 7 stimulus duration conditions (50, 100, 200, 400, 800, 1600, and 3200 msec) for dichromats and anomalous trichromats, and 5 conditions (all of the above except 1600 and 3200 msec) for trichromats.

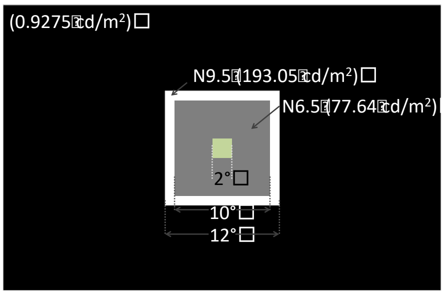

Figure 1. Experimental stimulus.

Table 1. The stimulus Colour.

V = 3, 5, 7, 9			1023 colors
H* = 5, 10	C = 2, 4, 6, 8, ···	480 colors	
H* = 2.5, 7.5	C = 1, 3, 6, 10, 14, ···	340 colors	
V = 4, 6, 8			
H* = 5, 10	C = 4, 8, 12, 16, ···	188 colors	
N1 − N9, R, G, B, C, M, Y		15 colors	

* H = R, YR, Y, YG, G, BG, B, PB, P, RP

Procedure

Each block began after 2 min of background adaptation. The colour patches and duration conditions were presented in a random order. The observer's task was to assign one of 14 colour names in Japanese (Red, Orange, Yellow, Yellow-Green, Green, Blue-Green, Blue, Purple, Brown, Pink, Aqua, Black, Grey, and White expressed in English) to the presented colour. If observers perceived a change in the colour appearance of the colour patch during the stimulus duration, they were instructed to choose the colour name of the colour patch just before it disappeared. There were no time restrictions for categorization, but one block of trials was set to last a maximum of 10 min. One session comprised about 30 (for trichromats) or 50 blocks (for dichromats) for each combination of colour patches and stimulus durations. Each observer performed 3 sessions.

One protanomal, one deutanomal, one deuteranope, and two trichromat observers participated in the experiment. Each observer was tested using Ishihara plates, the Panel D-15 test, the 100 Hue test, and the anomaloscope, and was assigned a colour vision type based on the results.

RESULTS AND DISCUSSION

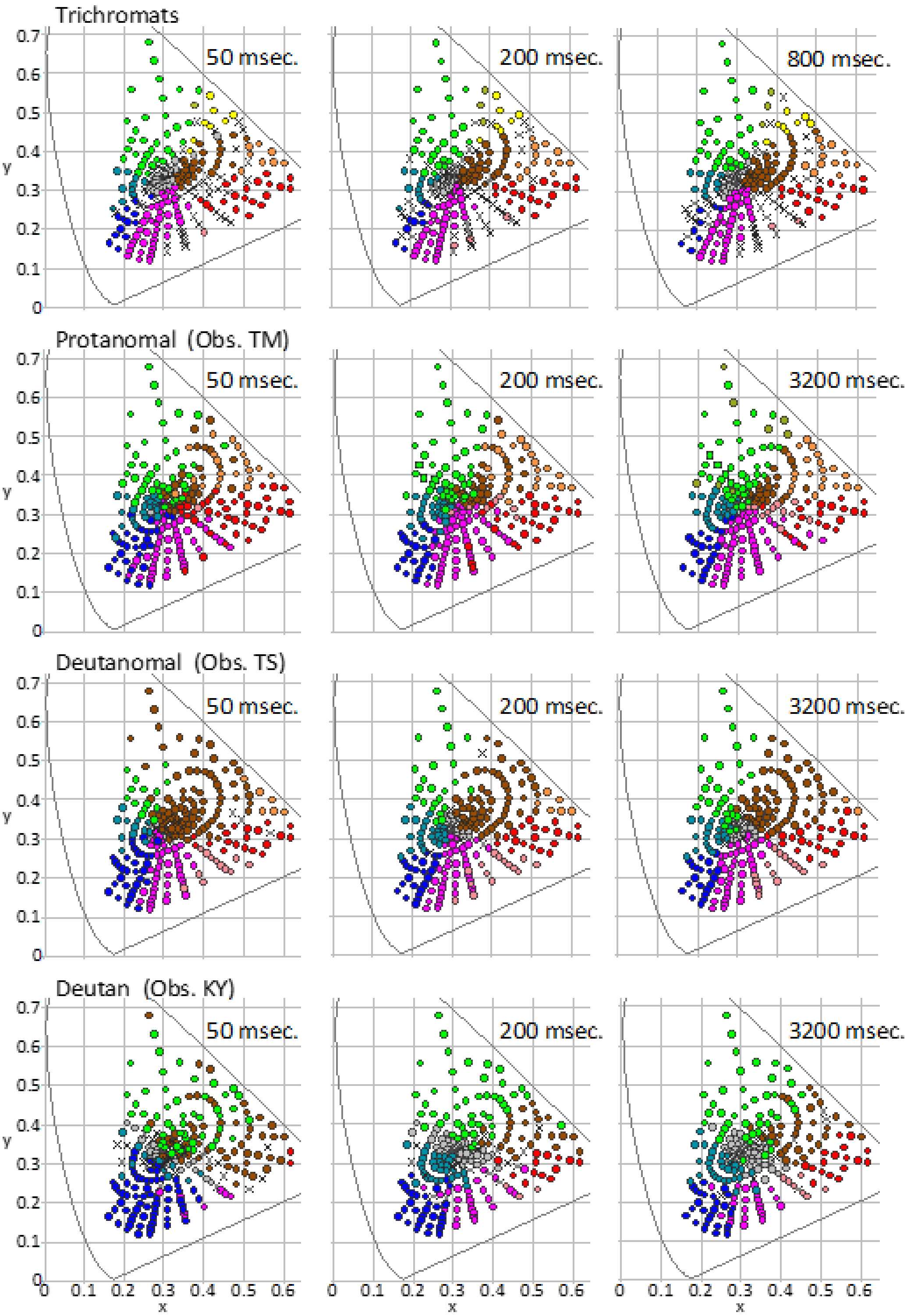

Figure 2. Examples of the regions of color categories for each type of color vision (V = 5)

Figure 2 shows the colour names given by the observers with each type of colour vision for stimuli with each stimulus duration when the Munsell value was 5. The symbol colour indicates the colour name response. The colour names for the presented colours were determined by the colour name given in at least four out of six summed responses for the 2 trichromats, and more than two of the three responses for the deutanomal and the deuteranope observers. The colour names given by the protanomal observer were determined by only 1 response because this observer did not complete 3 sessions. The X symbol indicates that the colour name could not be determined because the number of responses did not satisfy the criterion.

The colour category regions were localized and stable for all stimulus durations in the trichromats, who used eleven colour names in the lightness plane. No-consensus responses, which are indicated by the X symbol, were especially frequent in the region between Red and Purple among the trichromats. The colour category regions were also stable for the protanomal observer. Unlike the trichromats, the protanomal observer did not use Colour names with Yellow, and rarely used Grey.

The colour category regions were not stable for the deutanomal and deuteranope observers. There was a small region corresponding to Grey and a large region for Brown in the short duration conditions for the deutanomal observer. However, for the long stimulus duration, the regions corresponding to Grey and Green increased, while the region corresponding to Brown decreased. The deuteranope observer assigned a large region to four colours, Brown, Green, Grey, and Blue, in the short duration conditions. As the stimulus duration increased, the regions corresponding to Red and Purple increased for the deuteranope observer.

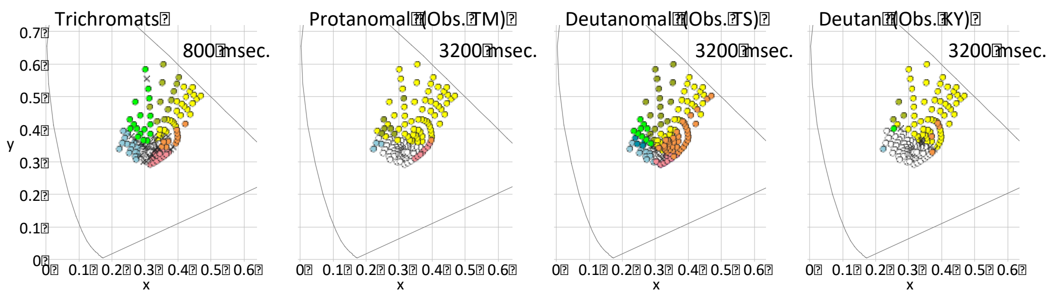

Figure 3. Comparison of the Colour category regions for each type of Colour vision (V = 9)

Comparing between colour vision types for the long stimulus duration, the regions corresponding to Brown, Red, and Green were similar between the trichromats and colour deficient observers. For the deutanomal observer, the colour name regions corresponding to Blue, Blue-Green, and Green were similar to those for the trichromats, while the deutanomal observer was similar to the deuteranope observer in terms of the small region corresponding to Orange and the large region corresponding to Grey for desaturated colours. For the protanomal observer, categorization was similar to that of the trichromats with the exception of judgments regarding Grey and Yellow.

Figure 3 shows the colour category regions for each colour vision type when the Munsell value was 9. When the Munsell value was 5, the categorization of the protanomal observer resembled that of trichromats, but when the Munsell value was 9, the categorization of the deutanomal observer resembled that of the trichromats, and that of the protanomal no longer resembled that of the trichromats. It is possible that the similarities in categorical colour perception in trichromats and anomalous trichromats are dependent on lightness and colour vision type.

CONCLUSION

We examined categorical colour naming in trichromat, anomalous trichromat, and dichromat observers. Our data indicate that categorical colour perception in anomalous trichromats resembles that of both trichromats and dichromats. Further investigation will be necessary to determine the contribution of anomalous cones to categorical colour naming.

ACKNOWLEDGEMENTS

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Spectroscopic Effects of Display Devices on the Human Non-Visual Characteristics

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ABSTRACT
Human response to the light with visual and non-visual system. The visual process recognizes brightness/Colour and the non-visual process is related to the circadian characteristics. The non-visual system is known to have maximum sensitivity to blue light; however, recent studies have shown that green light also affects this system. In this study, we spectroscopically analysed the effects of various wavelength regions of display devices on the non-visual characteristics. Our results show that at the same white colour temperature condition, the more blue wavelengths are red-shifted, and the green wavelengths are blue-shifted, the greater the effect on the non-visual systems. In addition, we synthesized green and red quantum dots with different peak wavelengths, and quantitatively compared the non-visual characteristics.

Keywords: *spectroscopy, non-visual, circadian, display*

INTRODUCTION

Much like the human ear has dual functions for hearing and sense of balance, the eye has a dual role in detecting light for vision and physiological responses.[1] The light perceived by the eye affects human in two different ways. One is the visual pathway connected to nervous system related to the reaction from visual recognition such as shape, colour and brightness of the object. The other is the non-visual or non-image-forming (NIF) pathway connected to endocrine system associated with the circadian rhythm of hormone secretion or other biological signals such as core body temperature.

Light-sensitive photoreceptors in the eye converts light (photons) into electro-chemical signals, which are then processed by neural circuits in the retina and transmitted to the brain.

Rod/cone cells are the photoreceptors in the retina, which act as sensors for visual process. On the other hand, intrinsic photosensitive retinal ganglion cells (ipRGCs) are the photoreceptors for the non-visual process, which contain a photopigment known as melanopsin.[2] The spectral sensitivities of visual and non-visual processes are different because the photopigments contained in the photoreceptors are different. While cone cell driven visual system are most sensitive to mid-wavelength green light (around 555nm), melanopsin-containing ipRGCs shows peak spectral sensitivity in the short-wavelength blue light (around 480 nm).[3]

The circadian rhythms are biological patterns with a period of approximately 24 hours. These biological clocks have evolved to synchronize the rotation of the earth (day/night cycle) and are mostly influenced by light environment. The suprachiasmatic nucleus (SCN) is the main clock, which is responsible for controlling and regulating of the neural and hormonal activities. The SCN, which is located superior to optic chiasm, receives input signal from non-visual process, and relays information to hypothalamic nuclei and pineal gland to modulate hormone secretion such as melatonin, cortisol etc.[4]

On the other hand, the circadian rhythms, which have been modeled for a long time through evolution, have been disturbed by various light information from artificial lightings and display devices in modern society. It has been reported that many problems occur when theses daily balances are broken. Typical problems we experience are sleep disturbance, depression, and jet lag. Furthermore, neurodegenerative diseases such as Alzheimer's disease have been reported to be associated with circadian rhythms.[5]

Therefore, many researchers have investigated how the spectral power density (SPD) and the light-timing correlates with non-visual characteristics of human. Several different biological action curves to the wavelength of the light, called the circadian sensitivity curves (C(λ)s) have been reported in previous publications.[6-8] These curves peaked at 460 nm, and the shape of was based on the data from the action spectrum for melatonin regulation. Thus, the circadian rhythm was most sensitive to nearly monochromatic blue light at around 450~480 nm. However, these blue lights have different effects on human depending the timing of the light stimulus. The blue light of late night suppresses melatonin secretion and delays the circadian rhythm, while the blue light of morning serves to restore the circadian rhythm. Therefore, we can say that the blue light around 460 nm is the circadian-rhythm-control wavelength.

In recent studies, however, only the blue light does not affect the circadian rhythm, because ipRGCs receive indirect synaptic input in the retina layers from rod and cone cells. These means that melanopsin and visual photoreceptors are complementary in modulating non-visual responses. They suggest that cone photoreceptors contribute substantially to non-visual photoreception for short-duration at low-irradiance light exposures and phase-resetting responses to 555 nm light exposure were larger than predicted for a response mediated by melanopsin.[9]

We analysed spectroscopic responses how the light of various wavelengths affects human circadian characteristics by calculation of circadian action factor (CAF) index. Especially, in terms of display devices applications, we investigated how different combination of red, green, and blue light sources with the same white colour temperature affect the non-visual properties. We also synthesized the perovskite quantum dots (QDs) with different wavelengths in the green and red region, and then made simple colour-by-blue display to compare their non-visual characteristics.

THEORY

To analyse the spectral power distribution (SPD) of white light, the luminous efficacy of radiation (LER) and the circadian efficacy of radiation (CER) values are calculated. As previously reported, the LER and CER can be defined as the ratio of the luminous flux to the radiant flux (S(λ)) and the ratio of the circadian luminous flux to the radiant flux (S(λ)), respectively. These values represent how the emission spectrum are visually and non-visually perceived at the human eye.

$$\text{LER}\ (lm/W) = \mathrm{K}_0 \int_{380\,nm}^{780\,nm} V(\lambda)S(\lambda) / \int_0^{\infty} S(\lambda) d\lambda \quad (1)$$

$$\text{CER}\ (blm/W) = \mathrm{K}_{c0} \int_{380\,nm}^{780\,nm} C(\lambda)S(\lambda) / \int_0^{\infty} S(\lambda) d\lambda \quad (2)$$

where V(λ) is the photopic spectral luminous efficiency function and C(λ) is the circadian spectral sensitivity function, which is correlated with human circadian perception. The K_0 (=683 lm/W) is the maximal spectral luminous efficacy for visual system and K_{c0} (683 blm/W) is the circadian efficacy value for the non-visual system. Among several suggested C(λ)s in previous reports, we used the C(λ) from Gall *et al* (ref. 8). The circadian action factor (CAF) is defined as the ratio of the CER to the LER (CAF = CER/LER), which is the biological action per unit of visual response. Therefore, CAF values can be used as the figure of merit for the circadian-rhythm-control power of the light sources. Please see more details about figures of merit in our previously reports.[10-11]

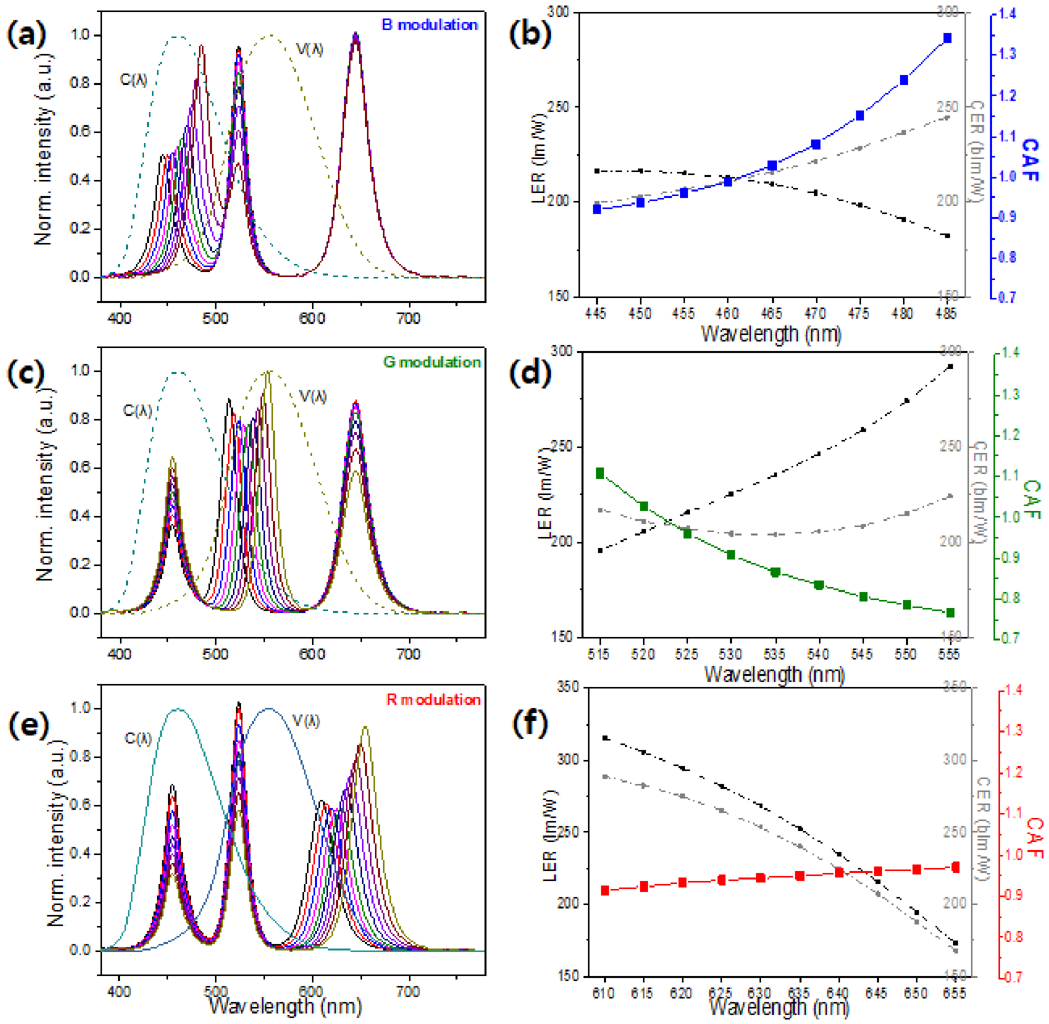
EXPERIMENTAL

We synthesized green and red QDs with different wavelengths to confirm the tendency of calculated CAF values. Perovskite QDs are promising light emission materials because of their unique properties, such as narrow emission, high photoluminescence quantum efficiency, and tunable wavelength. We synthesized materials with $CsPbX_3$ (X = Br, I) composition, controlling the concentration ratio of $PbBr_2/PbI_2$ for the green QDs (517, 526, 544 nm) and the red QDs (602, 620, 634 nm) as shown in Figure 2. We also fabricated QD films with UV-curable binders and colour converting package with blue LED (448 nm). Please refer to our previously published papers for detailed experimental procedures.[12]

RESULTS AND DISCUSSION

We generated various display white light sources with the different peak wavelengths of blue, green, and red with the same correlated colour temperature (CCT) by spectrum simulation as shown in Figure 1 (a), (c), and (e). The LERs, CERs, and CAFs were calculated using these simulated emission spectra as shown in Figure 1 (b), (d), and (f). In these figures, in the case of blue and red, CAFs increase as the wavelengths shifts to longer wavelengths, while that of green increase as the wavelength shifts to shorter wavelength. In addition, the changes of CAFs due to the changes of red peak wavelengths are not large, whereas the changes of CAFs with the variation of blue and green peak wavelengths are quite large. Thus, it can be seen that not only the blue wavelengths but also the green wavelengths affect the circadian characteristics in the polychromatic light sources.

This is because CAFs are determined by the ratio of the CERs to LERs, and the sensitivity curves of V(λ) and C(λ) overlap in the green wavelengths region. These findings indicate that the results of other clinical experiment[9] reports that the green wavelengths also affect the circadian rhythm of human can be explained from the viewpoint of spectroscopic analysis.



Figure

Figure 1: Simulated emission spectra by changing the (a) blue, (c) green, (e) red peak wavelengths. Calculated LERs, CERs, CAFs of (b) blue, (d) green, (f) red as a function of wavelengths.

In order to verify the simulated results by experiments, we synthesized QDs with various peak wavelengths (as shown in Figure 2), and then fabricated white LED packages with various green/red QDs combinations (for blue LED, a commercial chip is used). The measured optical properties and the calculated CAF values of these white packages are summarized in Table 1.

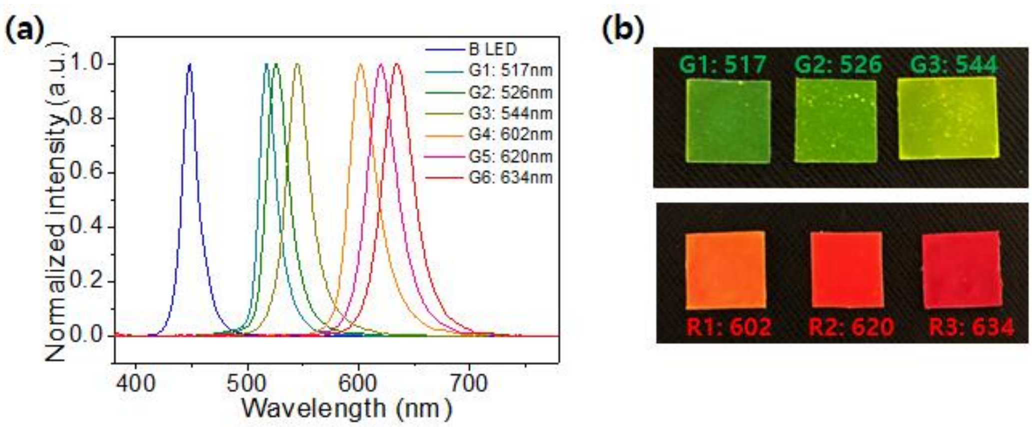


Figure 2: (a) Photoluminescence spectra of QDs. (b) Photographs of green and red QD films.

Comparing the calculated CAF values, the G1R3 white package, which is a combination of a relatively shorter green wavelength and a longer red wavelength, has the largest CAF value. Therefore, it can be said that a display device having such R, G, B colour combination is a circadian-rhythm-control device. Currently commercialized smartphone displays are divided into organic light-emitting diodes (OLEDs) and liquid crystal displays (LCDs), OLEDs are similar to G2R2 combination and LCDs are similar to G3R3 combination. Therefore, OLEDs with relatively large CAFs are suitable for controlling non-visual characteristics.

	G1R1	G1R2	G1R3	G2R1	G2R2	G2R3	G3R1	G3R2	G3R3
CIE x	0.316	0.317	0.316	0.317	0.316	0.317	0.317	0.316	0.316
CIE y	0.337	0.338	0.338	0.338	0.337	0.338	0.337	0.337	0.338
CCT(K)	6281	6246	6284	6260	6280	6256	6264	6297	6294
CAF	0.933	0.975	0.999	0.836	0.864	0.876	0.747	0.763	0.764

Table 1: Measured optical properties (Colour coordinates and CCTs) and calculated CAFs for the white LED package consisting of various green/red combination.

CONCLUSION

Using spectroscopic analysis, we showed that the green wavelengths as well as the blue wavelengths of light from a white light source such as a display device affect the human circadian rhythm. We also proposed the optimum combination of R/G/B wavelengths for increasing circadian rhythm-control power. These results can provide future research directions when designing a new display considering non-visible characteristics.

ACKNOWLEDGEMENTS

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Impressions of a Combination of Two Colours Are More Frequently Represented by Nouns Than Adjectives: In the Japanese Case

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ABSTRACT

We investigated whether impressions of two-colour combinations are represented more frequently by nouns or adjectives, and whether nouns or adjectives were recalled first. Many are of the view that one's impression of colours is represented by adjectives, but our experimental results showed that most prefer to use nouns instead of adjectives. The participants included 20 Japanese college students with normal colour vision. For visual stimuli, eight colours were used to prepare 64 patterns. The participants were asked to respond orally in an open-response format within eight seconds. The results revealed that significantly more nouns were recalled than adjectives ($p < .05$). Furthermore, significantly more nouns were recalled first ($p < .05$). These results suggest that nouns associated with colours are easier to recall than adjectives, which express the impression of colours.

Keywords: *two-colour scheme, impression, association, noun, adjective*

INTRODUCTION

When expressing the impression colours make on people, do they prefer using nouns or adjectives? It is believed that adjectives are normally used to express the impression of Colours. It appears that this stereotyped understanding also has an influence on the research methods employed to investigate the impression of colour. The semantic differential method (SD method), which utilizes scales between opposite-meaning adjectives is frequently used to explore colour impressions.

What do we first visualize when we see colours? Before various impressions come to mind, it is possible that we recall various things that are associated with colours. In order to determine what we visualize, it is necessary to eliminate the constraint of using only adjectives. In this paper, we considered an experimental design in which participants were given a few seconds to respond to an open-response format. This experimental design may enable us to verify that we do not use adjectives too frequently to express our impressions of colours.

In this short paper, the results of research based on the above mentioned, experimental design are discussed. These results were previously reported in Japanese (Tomita, 2016), and in English (Tomita, 2017). Unfortunately, there were a considerable number of mistakes in the graphs, data analysis, and interpretation of experimental results of these papers. In this paper, these mistakes are corrected. Although the research results are summarized again, there is a new interpretation of the results.

RELATED WORKS

Palmer et al. (2010,) in a study in which nouns were used to describe colours, found that colour preferences are correlated with colour associations. Kunugida *et al.* (2008) employed Putian's research method and examined the colour association process to determine the effects of ambient lighting design on psychological associations with colour. Ito and Oyama (2005) classified the functional relationship between the Munsell Colour system and colour emotions by employing the SD method and proposed a monochromatic emotional expression and an emotional expression of two-colour schemes. Furthermore, Makino and Takahashi (2012) created a three-colour scheme and examined the difference in impressions by using onomatopoeia with Coloured images.

It is believed that subjects use adjectives as well as nouns when responding to questions on colour schemes. Ito and Oyama (2005) employed the SD method in an experiment using nouns and found that nouns were not given due consideration. In a study on nouns, Kunugida *et al.* (2008) paid attention to the associative process, examined the design process of ambient lighting and its effects on psychological associations, and developed a design based on human impression evaluation.

METHODS

The experimental methods employed by Kunugida et al. (2008) were used in this study.

The participants included 20 Japanese college students (16 males and four females) with normal visual acuity and colour vision. Two-colour combinations were employed as visual stimuli to examine whether adjectives or nouns are recalled first. The materials included a total of eight coloured materials: six vivid colours, black, and white. The six vivid colours specified in the tone notation of Practical Colour Coordinate System (PCCS) are as follows: red: v2; orange: v5; yellow: v8; green: v12; blue: v17; and purple: v20. Equivalent Munsell Colour notations to the PCCS tones are listed in Table 1. Two-colour combinations of 64 patterns, including eight same-colour combinations, from these six Colours, white, and black were prepared. When each two-Colour combination was presented, the participants were asked to respond orally in an open-response format within eight seconds. The participants were given eight seconds rest between each set. The experimenters classified response-words into the following word classes: adjectives, nouns, and others such as onomatopoeia, verbs, and invalid words.

Table 1: Eight colours used in two-colour combinations

No.	Colour name	PCCS tone	Equivalent Munsell Colour notation		
			Hue	Value	Chroma
1	Red	v2	4R	4.5	14
2	Orange	v5	4YR	6	13.5
3	Yellow	v8	5Y	8	13
4	Green	v12	3G	5.5	11
5	Blue	v17	10B	3.5	10.5
6	Purple	v20	9PB	3.5	11.5
7	White	—	N10	—	—
8	Black	—	N0	—	—

RESULTS AND DISCUSSION

As shown in Figure 1, the experimental results revealed that the number of nouns used per visual stimulus was significantly larger than the number of adjectives used per visual stimulus ($p < .05$). Furthermore, as revealed in Figure 2, significantly more nouns than adjectives were recalled first ($p < .05$).

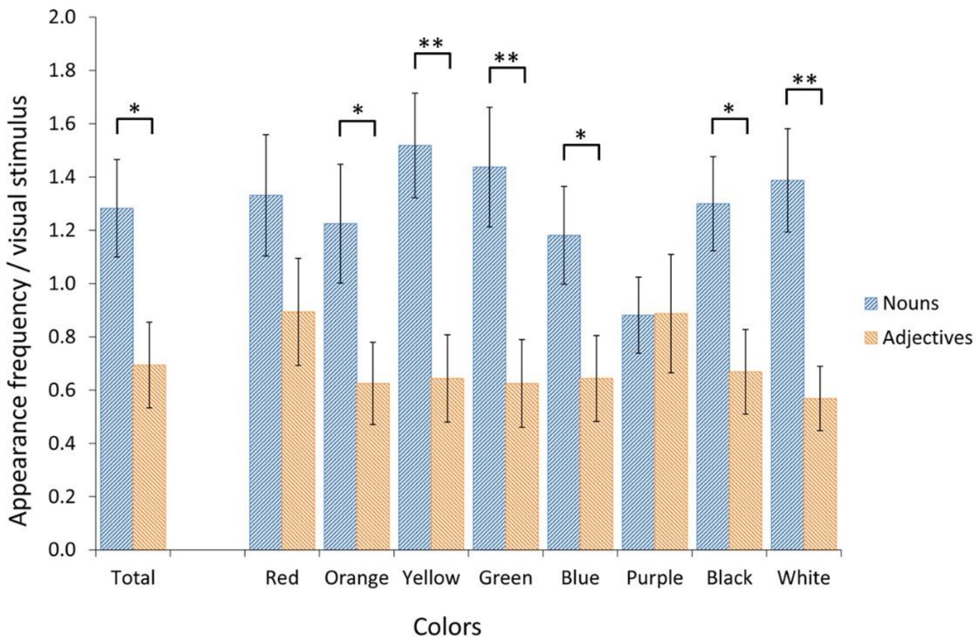

Figure 1: Appearance frequencies (per visual stimulus) of nouns and adjectives are arranged according to eight Colours and their averages. A single star (*) indicates $p < .05$. There were significantly more nouns than adjectives. Double stars (**) indicate $p < .01$.

The results of the statistical analysis revealed that nouns are more likely to be recalled than adjectives. We are of the view that the remarkable tendency to evoke colour-related memory is dependent on the length of the cognitive pathways or recall time. It may be easier to remember to nouns associated with colours because the cognitive pathways between colours and associated nouns are simple and connected directly. On the other hand, adjectives that are used to express an impression of colours are concepts formed from multiple memories related to colours. Therefore, cognitive pathways between colours and adjectives that express an impression of colours are expected to have many-to-one structures and multiple nodes. Furthermore, it is necessary to consider a person's state of mind when expressing an impression of colours by adjectives. Consequently, more recall times are necessary and it may be difficult to express them quickly.

As illustrated in Figures 1 and 2, with regard to red and purple, there were no statistically significant differences between nouns and adjectives. This may be because red is often associated with danger and any emotions related to danger may be recalled quickly. In Japan, the connotations of purple are often negative and may include dark, poisonous, cold, creepy, and sober. In our experiment, many negative adjectives were associated with purple. We expected negative feelings to occur more quickly than positive feelings; because purple often produces negative feelings in one's mind, purple may have a different tendency to the other colours.

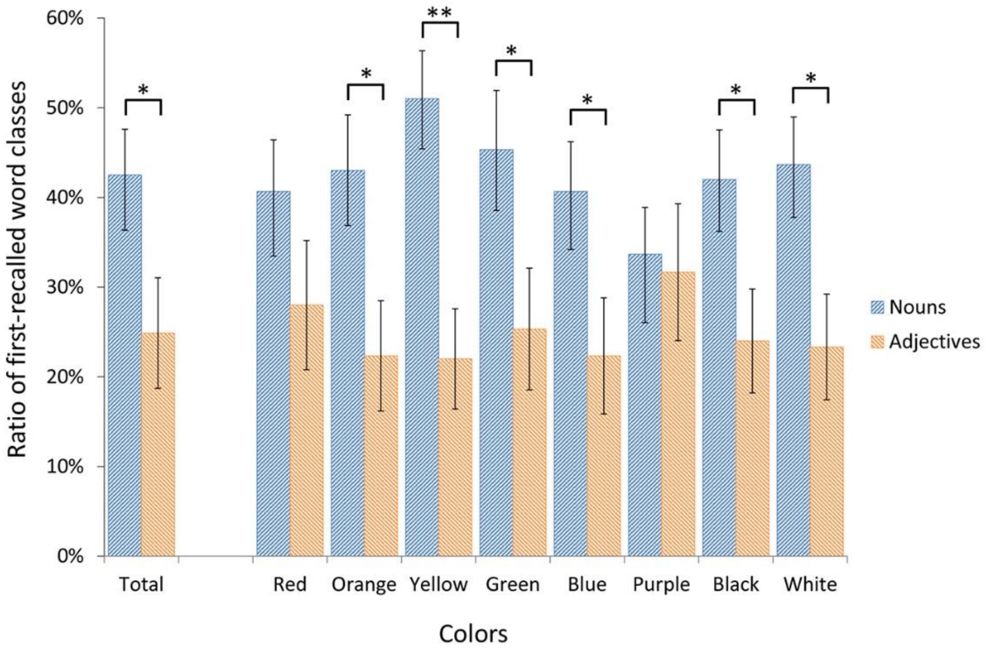

Figure 2: The ratio of first-recalled nouns and adjectives (for all visual stimuli) are arranged according to eight Colours and their averages. A single star (*) indicates p < .05. There were significantly more nouns than adjectives were recalled first. Double stars (**) indicate p < .01.

CONCLUSION

We investigated the frequency of the appearance of nouns and adjectives to express impressions of two-colour combinations. We also investigated whether nouns or adjectives were recalled first. Our experimental results revealed that nouns associated with two-colour combinations are more likely to be recalled than adjectives to express impressions of two-colour combinations.

We believe that our results are due to the length of the cognitive pathways or recall time to evoke colour-related memory. Our results suggest that colour preferences may depend on coloured objects and entities expressed by nouns rather than colour impressions expressed by adjectives.

It is our intention to examine the influence of age and gender on recalled nouns and adjectives as well as our tentative theory on cognitive pathways, memory structure, and colour preferences.

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A Study on Light Adaptation Time and Glare Evaluation of the Elderly

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ABSTRACT

Aging causes the eyes to accumulate waste matter in the eyes, reducing the clarity of vision and increasing glare. In addition, visual functions relating to the light degrades, making it difficult for the elderly to rapidly adapt to changes in brightness. Light adaptation refers to the function of the eyes to adjust to the change from darkness to brighter environments. In general, the rod cells work to adapt to brightness changes for twenty to forty seconds through the rapid α-adaptation mechanism, which in turn causes the slower β-adaptation in the cone cells to complete the light adaptation process. More aged people have increased light adaptation time (Kline & Schieber, 1985), and Coile CD et al. have reported that elderly subjects in their seventies experienced more than ten minutes of delayed adaptation sensitivity compared to the younger subjects in their twenties. Conventional lighting environments use on/off controls that instantly changes the intensity of light, making it difficult for the eyes to easily adapt. Recent rise in the LED lighting technology, however, enabled dimming and sensing switches that can provide relative visual comfort in regard to lighting.

Keywords: *Senior Citizen, Lighting Environment, Glare, Light Adaptation, Perceptual object*

INTRODUCTION

BACKGROUND AND PURPOSE OF THE STUDY

The global interest for the optic health is increasing. According to data from Statistics Korea, elderly population over the age of 65 in Korea will increase from 14.3% in 2018 to 41.0% in 2060, making the country into a super-aged society. This rate of growth in the aged population is more rapid than in other countries. Most people begin experiencing farsightedness in their mid-forties, requiring magnifying glasses. With the aging process, waste matter accumulates in the eyes, reducing the clarity of vision in the eyes, causing glare and lack of distance adjustment, making it difficult to transition from looking at things far away to viewing those nearer. In addition, visual functions relating to the light degrades, making it difficult for the elderly to rapidly adapt to changes in brightness. Light adaptation refers to the function of the eyes to adjust to the change from darkness to brighter environments. In general, the rod cells work to adapt to brightness changes for twenty to forty seconds through the rapid α-adaptation mechanism, which in turn causes the slower β-adaptation in the cone cells to complete the light adaptation process. More aged people have increased light adaptation time (Kline & Schieber, 1985), and Coile CD et al. have reported that elderly subjects in their seventies experienced more than ten minutes of delayed adaptation sensitivity compared to the younger subjects in their twenties. It must be understood that visual aging of the elderly people can make them vulnerable in environmental terms. Lighting environments that are tailored to the visual characteristics of the aged population must be applied to minimize threat factors that can arise as a result of weaker vision.

As such, the current study aims to evaluate the visual recognition, brightness recognition, and glare recognition in frequently habited indoor lighting environments, experienced by a group of senior citizens over the age of sixty-five and that of younger people in their twenties and thirties. The results of the current study can be used to establish a database for understanding lighting environments that are adequate for living spaces for the elderly.

RESEARCH METHODS

The current study consists of the following three phases:

Step 1		Step 2		Step 3
· Understanding visual aging and characteristics · Differentiation of research	▶	Accurate time measurement and glare evaluation	▶	Analyzing Results and Drawing Conclusions

THEORETICAL CONSIDERATIONS

LEADING RESEARCH ANALYSIS

A comprehensive review of previous literature on colour and lighting environment for the elderly reveals that studies on colour recognition characteristics have been continuing robustly. In addition, some papers suggest lighting environments for living spaces for the elderly, but it seems that these proposals are not sufficient in terms of brightness, as the ages of the elderly people are significantly higher in today's world.

AGING OF VISION

When they are awake, humans almost entirely rely on vision. Due to this heavy reliance on this single system, the loss of vision is the second-most threatening factor to human survival, only preceded by cancer (Verrillo & Verilo, 1985). Although the level of visual damage may differ in seriousness, in the end, all humans experience visual degradation that require treatment or that can be obstructive in carrying out daily routines (Kline & Schieber, 1985). There are two main changes that take place in terms of visual functions of the human body. The structural changes begin to impact the visual capacity during the middle ages. The most important structural change is the reduction in the ability adjust the vision, which relates to the capacity of the eyes to adapt to the volume of lights in the environment and obtain focus. These structural changes are the main causes of two conditions: Cataracts refer to the condition in which the crystalline lens become murky, preventing the light to go through the eyes and refract to form images on the retina. The end result is a symptom in which the vision becomes cloudy, as if there is a persistent fog in the visual environment.

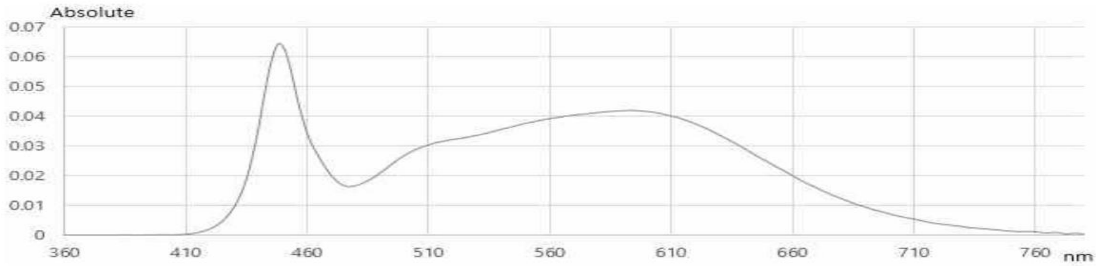
Glaucoma is a disease in which the vision is lost due to the malfunction of the optic nerves that deliver the light signals to the brain. Damage to the optic nerves cause damage to the vision, which, if left untreated, can cause severe loss of vision.

COMPLIANCE

Adaptation is a function of lighting changes, which is caused by the sensitivity of the eyes. Adaptation is categorized into dark adaptation in to the darker environments and light adaptation to lighter environments. For example, going into a dark theatre from a bright outdoor environment requires dark adaptation, while going back out into the outdoor requires light adaptation of the eyes. The time required to complete these two types of adaptation increases with age (Kline & Schieber, 1985). In addition, the last level of dark adaptation is lower in the elderly population (Wolf, 1960). This means that as people age, more time is required to adapt to the changes in the lighting level, and the elderly people are vulnerable to the environmental risks in the first few minutes required for adaptation to such changes. For example, older drivers require more time to visually recover from the headlights from the oncoming traffic, which often makes them miss critical information on highways.

EXPERIMENTAL VARIABLES AND EXPERIMENT PARTICIPANTS

Category	Content
Name	Grid Lighting(EA:55)
Module size	300 × 300mm
LED array	12 Serial ×12 Parallel (PCB, 2PCS), 144 EA
Used Power	Convert from LED converter to DC 48V
Power consumption	PURE 30 W, WORM 30 W
Communication method	DMX 512
Number of Channels	CH I: PURE, CH 2 : WORM



P.W nm	449	Abs.	0.064

PW : Peak Wabalength / Abs. : Absolute

Table 1: Details of the experimental light source.

EXPERIMENTAL ENVIRONMENT

The experimental space and assessment environment were composed of a dark room with a dimension of 3250 × 5080 × 2700mm. The lighting environment was configured with 55 grids (330 x 30330mm per grid) to form large-surface lighting. The room setup refrained from including furniture and provocative Colour elements that could influence the visual assessment.

EXPERIMENTAL LIGHT SOURCE

Table 1 shows the detailed specifications of the light source, and the blinking speed was set at one second to measure the light adaptation time of the experiment subjects.

EVALUATION TARGET

In the experiment, the researchers measured the adaptation time right after the light was turned on. During the evaluation, the subject and the assessment target object was located at two meters of each other. Table 2 indicates the variables regarding the lighting environments and assessment target objects.

Lighting environmen	Lighting physical quantity	Size to evaluate	Font size
colour temperature(K)	3000 K, 6000 K	3cm×3cm	80 pt
	0 lx > 10 lx	1.5cm×1.5cm	44 pt
Illuminance(lx)	0 lx > 100 lx	Font	Evaluation suggestion word
	0 lx > 1000 lx	Arial	5,6,8,9,3,0

Table 2. Evaluation target and lighting volume.

CONFIGURING PARTICIPANTS

The experiment was conducted on seven adults in their 20s and 30s, as well as 6 elderly people over the age of 64. Table 3 shows their details. During the assessment, the participants were made to adapt to the environment in the dark room for over one minute. They were directed to read the letter attached on the wall in front of them when the brightness in the room was suddenly adjusted. At this time, the experiment administrator checked whether the subjects' answers were correct, in addition to measuring and recording the amount of time required for light adaptation. Furthermore, the administrator asked the subjects to provide a score out of four points as to the level of experienced glare (0 for being able to recognize the letter and the environment, 1 for being able to accept the glare, 2 for disliking the glare, 3 for not being able to tolerate the glare), and recorded the results on the assessment sheet.

Division	Group of 20 to		Groups aged 65 and older	
Gender	Man	Woman	Man	Woman
	3 people	4 people	4 people	2 people
Age	21 to 25 years		65 to 71 years	
Vision	Corrected vision 1.0 or higher			
Glasses worn	Wearing	Not worn	Wearing	Not worn
	2 people	5 people	1 people	5 people
Total	7 people		6 people	

Table 3. Configuration of participant.

RESULTS AND ANALYSIS

TECHNICAL STATISTICAL ANALYSIS RESULTS

Table 4 shows the results of average analysis on the younger and older groups. The younger group required 1.17 to 1.99 seconds to recognize the assessment target object after lights with colour temperatures of 3,000K and 6,000K were turned on, respectively. In contrast, the older group required 2.65 to 9.2 seconds in the same conditions, indicating that older populations require more than four times the light adaptation time compared to their younger counterparts. In addition, the younger group rarely exhibited errors in recognizing the assessment target letters, but the members of the older group made more errors in less bright environments and when looking at smaller fonts. In glare assessment, both of the groups were able to recognize the target letters or accept the level of glare in most lighting environments. However, they did not like the more intense lighting environment in 1,000lx.

In sum, the visual aging in the elderly people delay the light adaptation time, in addition to increasing the number of errors in terms of recognizing the assessment target letters. Based on this, the current study concludes that the safety and visual security must be guaranteed by increasing the brightness of the environments when planning living spaces for the elderly people.

Colour temperature (K)	Illuminance (lx)	Font size	Group of 20 ~ 30 Time to respond to positive signs	Error count	Glare	Groups over 65 Time to respond to positive signs	Error count	Glare
3000 K	10 lx	44 pt	1.764	0	0	4.373	4.833	0
	100 lx		1.992	0	0.667	3.673	3.167	0.667
	1000 lx		1.578	0	1.667	5.492	1.667	1.667
	10 lx	80 pt	1.613	0	0	6.657	1.667	0
	100 lx		1.568	0	0.667	9.743	0.5	0.667
	1000 lx		1.253	0	1.667	4.393	0	1.667
6000 K	10 lx	44 pt	1.253	1.17	0	2.657	4.667	0
	100 lx		1.295	0	0.667	9.208	2.333	0.5
	1000 lx		1.557	0	1.667	8.602	0.167	1.667
	10 lx	80 pt	1.327	0	0	5.698	1.5	0
	100 lx		1.187	0	0.667	5.277	0.5	0.5
	1000 lx		1.171	0	1.667	4.097	0	1.667

Table 4. Technical statistical analysis results.

SIGNIFICANT DIFFERENCE TEST RESULT

In order to verify whether the same environmental condition and subjects result in significant differences between the groups, Mann-Whitney's U test was conducted. The results are as indicated in Table 5.

In 10lx light with the colour temperatures 3,000K and 6,000K, respectively, some older experiment subjects were not able to recognize the assessment targets. Because of this, the significance level of the light adaptation time could not be obtained. In addition, for the errors made in recognizing letters with a font size of 44pts under10lx and 100lx lights with Colour temperatures 3,000K and 6,000K, respectively, the significance probability (p) of the groups was 0.05 (significance level 5%), indicating a statistically significant difference. Furthermore, under all lighting environments, the significance probabilities (p) regarding the glare experienced by the two groups were 0.05 (significance level 5%) or higher, showing that there is no significant difference between the two groups in terms of glare.

Illuminance (lx)	Font size	3000 K Time to respond to positive signs	Error count	Glare	6000 K Time to respond to positive signs	Error count	Glare
10 lx	44 pt	-	0.016*	1.000	-	0.018*	1.000
100 lx		1.000	0.021*	1.000	-	0.007*	0.575
1000 lx		0.055	0.140	0.859	0.006*	0.317	0.859
10 lx	80 pt	0.055	0.022*	1.000	0.054	0.059	1.000
100 lx		0.006*	1.000	1.000	0.010*	0.317	0.575
1000 lx		0.006*	1.000	0.859	0.004*	1.000	0.859

* : Less than 0.05, **A level of 0.05 or higher**, **Unable to determine significance level**

Table 5. Significance difference test result.

CONCLUSION

The objective of the current study was to assess the visual recognition, as well as the experienced brightness and glare in changing lighting environments by looking at a group of subjects in their 20s and 30s and a group aged 65 or higher.

1. The older group took at most 4 times more time to recognize the assessment target after light adaptation compared to the younger group. In addition, the younger group rarely exhibited errors in recognizing the assessment target letters, but the members of the older group made more errors in less bright environments and when looking at smaller fonts.
2. In glare assessment, both of the groups were able to recognize the target letters or accept the level of glare in most lighting environments. However, they did not like the more intense lighting environment in 1,000lx.
3. In terms of significance testing, for the errors made in recognizing letters with a font size of 44pts under10lx and 100lx lights with colour temperatures 3,000K and 6,000K, respectively, the significance probability (p) of the groups was 0.05 (significance level 5%), indicating a statistically significant difference. Furthermore, under all lighting environments, the significance probabilities (p) regarding the glare experienced by the two groups were 0.05 (significance level 5%) or higher, showing that there is no significant difference between the two groups in terms of glare.

Based on this, the continuation of the aging process in the society must be addressed by guaranteeing the safety and visual security of the elderly population through higher brightness of the environments considered in plans for their living spaces.

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Rethinking Baker-Miller Pink through Gender Studies

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ABSTRACT

Alexander Schauss recognised in 1979 the Baker-Miller Pink (BMP) as a peculiar shade of pink able to soothe the mind and decrease muscular strength. It is currently used on the walls of several prisons and police custody facilities where it is expected to help calming the inmates. Through various media appearances, BMP became a cultural phenomenon, an "urban legend." This article intends to rethink the BMP, from its theorisation to its implementation, through a bibliographical synthesis of the works done on it. It is a rereading from the point of view of gender studies, by questioning the importance of the gender of the experimental subjects recruited (mainly men) and the context (male prison) of the experiments. It therefore rethinks the use of pink as an ideological reaffirmation of gender stereotypes, and as a reactivation of homophobia as a system of exercise of power over individuals subject to the "make the man" injunction.

Keywords: *Baker-Miller Pink, colour effect, masculinity, homosexuality, patriarchy*

INTRODUCTION

In August 2016, the fashion brand Vollebak launched the "Baker-Miller Pink Relaxation Hoodie," a pink sweatshirt which includes a hood completed by a mesh mask that can be entirely zipped up on the face. This is supposed to allow a certain exclusion from the world without causing any sense of claustrophobia. This new product launch quickly rekindled the debate about the Baker-Miller Pink (BMP). Alexander G. Schauss recognised in 1979 the BMP as a peculiar shade of pink able to soothe the mind and decrease muscular strength. It is actually used on the walls of several prisons and police custody facilities, particularly in Switzerland and the United States, where it is supposed help calming the inmates. Through various media appearances, it became a cultural phenomenon that could even be described as an "urban legend" (Alter, 2012).

Figure 1: “Baker-Miller Pink Relaxation Hoodie”, 2016 (©Vollebak)

THEORY

Numerous studies conducted by Schauss intend to prove the soothing effect of BMP on subjects. However, the results are often not significant in the opinion of the authors (Pellegrini, Schauss and Birk 1980; Pellegrini, Schauss, Kerr and Ah You 1981). However, this did not prevent them from repeating their experiences (over and over). Other researchers have also looked in vain for a possible effect of colour on muscle strength or aggressiveness (Profusek and Rainey 1987; Gilliam and Unruh 1988).

A 2015 study raised the question of experimental bias in the recruitment of experimental subjects (Genshow, Noll, Wänke and Gersbach 2015). In fact, Schauss performs its experimentation on women only once, in a study that did not lead to satisfactory results (Pelligrini and Schauss 1980). In both studies with prisoners, he obtained temporary results: the rate of aggressions (insults, agitation, attempted attacks) of the prisoners fell at the beginning of the experiment, but it went back up to exceed the initial rate after several weeks. Schauss and his peers concluded on a surprise effect on the prisoner’s discovery of the confinement cell with pink walls while they were usually white (Pelligrini, Schauss and Miller 1981).

EXPERIMENTAL

We shed a new light on the studies conducted by Schauss through the lens of gender studies, and particularly through Arnaud Gaillard’s work (2015) on the prison environment. He stated: “the question of gender is at the heart of the problem of prison confinement”: the male prison is thus akin to a “conservatory of masculinity” set up in response to the submission and therefore of the remasculinization situations that impose prison confinement and penitentiary punishment. Stereotypes of male gender are then exacerbated: physical and moral strength, domination, violence, and heterosexual policing. Virility must be manifested in the appearance and attitude (“to make the man”) that is to say by the muscular mass, the presence of tattoos, the deep voice, etc.

In order to guarantee a universal gender division within this monosexual space, the prisoners have set up a system of hierarchy articulated around the homosexuality. The dominant ones are those who have a heterosexual sexuality considered as masculine, the "penetrants", while the dominated ones are those who have a homosexual sexuality considered as feminine, the “penetrated”. This system guarantees a stable symbolic order of the heterosexuality around of which the binarity and the gender complementarity is articulated. But homosexuality in prison is more symbolic than real, and it is homophobia that is more present. Homophobia plays the role of authority and of guardian of the heterosexual norm, establishing a hierarchy among inmates, which insures a position of power to the most virile among them (Hoquet 2009).

RESULTS AND DISCUSSION

In this context, we must rethink the effects of the BMP on prisoners. Since the beginning of the twentieth century, pink is considered in the West as the colour of the feminine (Paoletti 2012). As feminine colour, pink also became an anti-masculine colour (Mollard-Desfours 2002) which, when associated with men, leads to a suspicion of homosexuality. Imposing pink to the detainees could be seen as an empowering attempt from the jailer to deprive the prisoners of their male attributes. The gender signifiers have a stronger impact in prison, and pink thus become a questioning of their capacity “to be a man” and “to make the man” within the prison community. By losing the symbolic attribute of their masculinity, they also lose their dominating status in the prison universe towards the dominated, or, to put it more simply, the homosexual ones.

The homosexual man is symbolically closer to women because his sexuality presupposes him as a penetrated subject (Eribon 1999; Hoquet 2009). Pink can thus be used to signify the homosexuality of a man, as during the deportations of gay men in the Second World War.

In the early 1980s, the visitors’ locker room of the Kinnick Stadium in Iowa was painted in pink by the coach Hyden Fry who put the Schauss studies into practice to reduce the strength of the opponents to win matches more easily. In the renovation of 2005, the visitors’ locker room was painted over in pink, and pink lockers and toilets to match the walls, thus raising feminist student’s outcry.

Indeed, this choice could also been interpreted as a form of misogyny and homophobia, since in sports, playing “like a girl” or “like a fag” means playing poorly. Understood as masculine, sports operate as the foundation of patriarchal’s authority power. Painting the locker room in pink is therefore a symbolic form of emasculation of the opponent, not only because pink is associated with the feminine, but also because the sport is co-constructed with masculinity (Buzuvis 2007).

Figure 2: The pink visitors’ lockers of the Kinnick Stadium of Iowa (©NCAA)

Joseph Michael Arpaio, sheriff of Maricopa County in Arizona since 1992, runs the Maricopa County Jail. This prison became infamous especially because of the detention conditions he set up. He is especially known for forcing the prisoners to wear pink underwear (boxers and socks), “to prevent inmates from stealing the white shorts” (Arpaio 2015).

By emphasizing again, the interactions between the pink colour, the feminine symbolism and the context of the prison highlighted with the BMP, this measure could also be apprehended from the angle of the humiliation of the prisoners, since they are deprived of their virile signifiers. In addition, the Sheriff Arpaio also banned erotic magazines and bodybuilding equipment within the prison, two tools allowing prisoners to perform their masculinity in this conservatory of masculinity.

Figure 3: Inmates in the Maricopa County Jail, 2016 (©Elizabeth Stuart)

CONCLUSION

The effect of the BMP is therefore the result of the combination of the feminine symbolism of ink with an exclusively masculine environment (male prison, custody facilities) or closely associated with masculinity (sport). From this combination emerges the stigmas of male homosexuality which — in a heterocentric patriarchal context — is negatively perceived as inferior to a masculine norm. More than a scientific research, the BMP has become a marketing argument for selling products or promoting institutions or their leaders. This highlighting of the BMP by the media is obviously made possible only because gender relations are central in all spaces and at all times. By drawing attention to the symbolic jeopardizing of masculinity by the colour pink, the patriarchal power reaffirms the symbolic and social order of the sexes around a segmental element. More than being the colour of the feminine, pink allows to detach the masculine from what is not (women or gay men), and thus to create a clear separation between the dominant and dominated categories. It is possible to apprehend the BMP as an instrument of patriarchal power, which would explain why its popularity persists despite its scientific non-existence.

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The Effect of Artificial Light and Wall Colours on User Preference: Living Room Example

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ABSTRACT

In this paper, the results of an experimental research to determine the user's colour preference of living room and the effects on the colour design of the lighting under different light sources were presented. The method of the research can be summarized as the presentation of small painted samples prepared according to the Munsell Colour System to the subjects, the determination of the wall colour preferences for the living room and the obtained evaluation of findings. The results of the study showed that there were differences in colour preferences under different light sources.

Keywords: *Lighting, Colour of light, Living room, Wall colour, Colour preference*

INTRODUCTION

Indoor surfaces (ceilings, walls, flooring) play a role in the perception of a space. However, the effect of wall is stronger than the ceiling and floor surfaces because the walls cover a larger area in the field of vision. In this context, wall colours are more important both for aesthetic harmony with the interior fixtures and for the colour preferences of the users. The identification of a space wall colour generally is determined according to an architect and the user preferences in the direction of the function of the space, trends in current fashion, culture, age, gender, and so on.

THEORY

The perceived colour of a surface varies depending on the colour properties of the light source. For this reason, the technical features of the lighting system and the light sources are important when selecting the wall colour. If the number and the position of luminaires and the colour of the light change the perceived colours of the space surfaces will change.

The purpose of the study is to determine whether the colour preferences of the users could change under different artificial light sources. In this paper, the results of an experimental research were presented within the effect of the different light sources on interior colour designs and the determination of the user preferences for living room wall colours.

EXPERIMENTAL

The aim of this study is to briefly summarize the following steps for the purpose of determining the users' wall colour preference and the effect of different light sources on the preference of wall colour for a living room.

- Preparation of an experiment room having only artificial light sources,
- Selection of two different light sources with different colour characteristics and establishment of lighting system in the experiment room,
- Preparing small samples for wall colour
- Determining user preferences by showing coloured samples to the subjects,
- Evaluating user preferences for wall colour in the living room.

The study was carried out in a space (3 m in width, 4 m in length, and 2.95 m in height) with a table and a chair, organized as an experiment room in a university in Istanbul. The walls of the experiment room were painted with medium gray colour (N 6/0) and the work table was wrapped with medium grey (N 5/0) fabric to avoid interference with the interior colours when the subjects decide on the wall colour. The ceiling is white (N 8/0 of the speckle), the floor colour is high value, low-saturation yellow (5YR 9/2) ceramics. The window in the room was closed with a grey jalousie and daylight was blocked. In the experiment room, there are two lighting luminaries having two different light sources. One of the light source is a compact fluorescent lamp with a colour temperature of 4000 K and a colour rendering index (Ra) of 80, called the light source A. The other one is an incandescent halogen lamp with a colour temperature of 2700 K and a colour rendering index (Ra) of 100, called the light source B. The rendering of the light source B is 100, meaning that colours are correctly perceived under the light B. The average illumination level of the A and B light sources on the table plane is 450 lx.

The colour samples presented to the subjects have ten hues (5R, 5Y, 5G, 5B, 5P, 5YR, 5GY, 5BG, 5PB, 5RP) that follow each other in equal steps. Every hue page have different values (6, 7, 8, and 9) and chromas (2, 4, 6, 8, 10) by using Munsell Colour System. The coloured samples were prepared in two dimensions (small 3.5 x 3.5 cm) and (large 7 x 7 cm) painted with gouache paint. The 7x7 cm samples were separately pasted on grey cartons (N 5/0; size B5). The 3x3 cm samples were pasted and grouped on grey cartons (N 5/0); size A4) for the same hue and ten different hue pages were arranged. A total of 94 colour samples are shown in the survey (Table 1).

A total of 61 participants, 31 females and 30 males, consisting of university students and specialist academics from various disciplines aged between 18 and 75 participated to the survey. All subjects were tested for colour vision deficiencies prior to participation using Ishihara colour vision test. It was determined that the subjects had no colour defect of vision.

Table 1: The hue, value and chroma for the Munsell Colour notations

	5R RED	5YR ORANGE	5Y YELLOW	5GY GREEN-YELLOW	5G GREEN	5BG BLUE-GREEN	5B BLUE	5PB PURPLE-BLUE	5P PURPLE	5RP RED-PURPLE
VALUE/CHROMA	9/2	9/2	9/2 9/6 9/10	9/2 9/6 8,5/10	9/2	9/2	9/2	9/2	9/2	9/2
	8/2	8/2 8/6 8/8	8/2 8/6 8/10 8/12	8/2 8/6 8/10	8/2 8/6	8/2 8/4	8/2 8/4	8/2 8/6	8/2	8/2
	7/2 7/6 7/10	7/2 7/6 7/10 7/12	7/2 7/6 7/10	7/2 7/6	7/2 7/6 7/10	7/2 7/6 7/8	7/2 7/6 7/8	7/2 7/6	7/2 7/6 7/8	7/2 7/6
	6/2 6/6 6/10 6/12	6/2 6/6 6/10	6/2 6/6	6/2 6/6	6/2 6/6 6/10	6/2 6/6 6/8	6/2 6/6 6/8	6/2 6/6 6/10	6/2 6/6 6/8	6/2 6/6 6/10

In the study of determining the colour preferences, ten hues of colour pages were shown to the subjects and they have preferred from one of the hue page and marked survey paper. Then, a total of 10 colours selected for each hue page were given as large size samples (on A5 size gray cardboard, 7x7 cm size) and were requested most preferred colour from them. The process was repeated under light sources A (4000 K, Ra 80) and B (2700 K, Ra 100).

RESULTS AND DISCUSSION

The responses obtained from the survey are shown in the colour hue context in the graphs in Figures 1 and 2. The users preferred warm colours such as red (5R), yellow (5Y), orange (5YR), blue (5B) and purple-blue (5PB) hues having high-value and low-chroma colours under light source A. Under the light source B, the high-value and low-chroma colours of the red (5R), yellow (5Y) and blue (5B) colours were preferred. The green (5G) colour hue family was not preferred under the light source A (Figure 1)

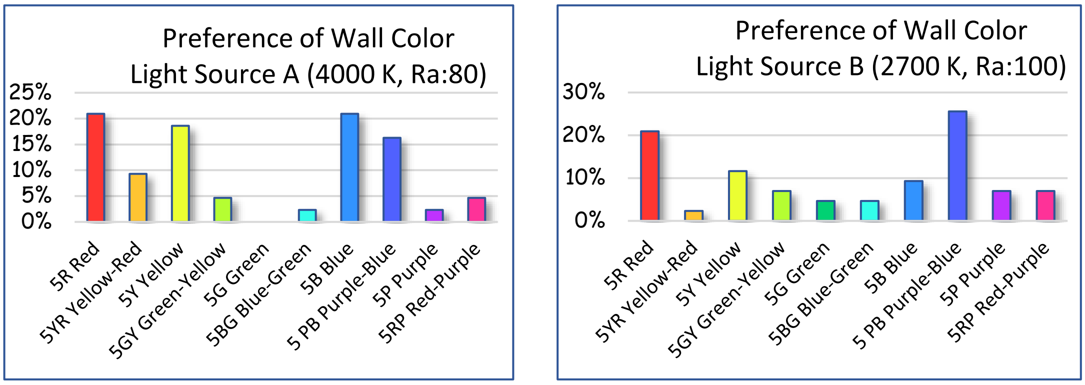

Figure 1: Type preferences under light source and B

According to the results of the survey, 28 % of the subjects preferred the same colours in terms of hue, value and chroma components under both A (4000 K, Ra: 80) and B (2700 K, Ra: 100) light sources. However, 38 % preferred the same colour (red (5R), yellow (5Y) and purple-blue (5PB)) hues with different values and chromas.

Both male and female subjects had similar preferences under both two different light sources. Female subjects preferred medium and high value and low saturation colours of blue (5B) and purple-blue (5PB) with high value, low saturation of red (5R) and yellow (5Y) hues in wall colour selection under the sources of A and B. Male subjects selected the high values and chromas of red and yellow hues under light source A and purple-blue hue wall colours under light source B. Females never preferred green hue family and males never preferred green, purple and red-purple hues (Figure 2, Figure 3).

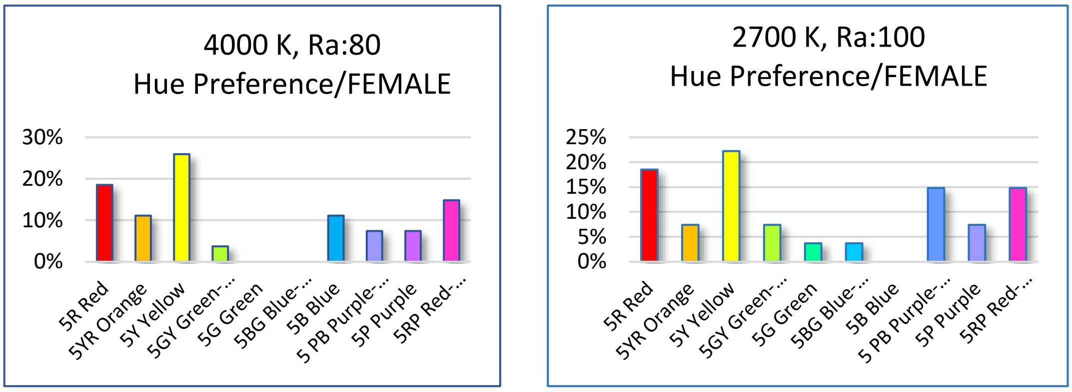

Figure 2: Preference under A and B light/Female

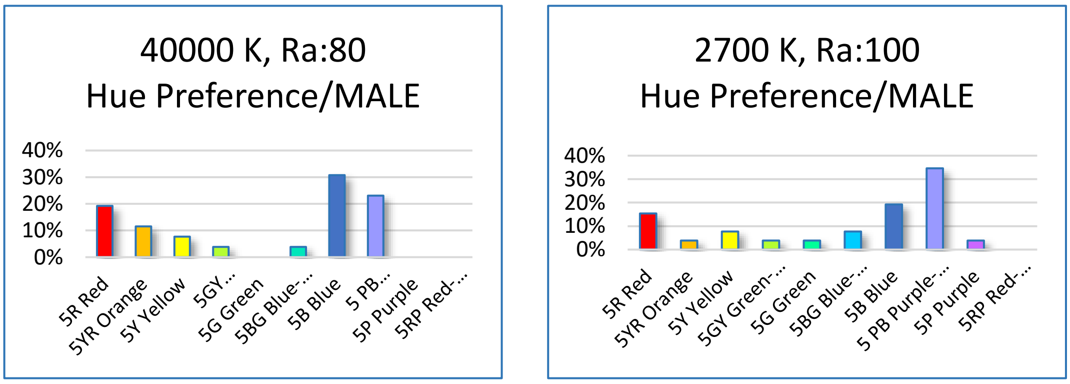

Figure 3: Preference under A and B light / Male

CONCLUSION

The living room wall colour preference survey which was carried out with a total of 94 colours in ten hues having different values and chromas, was repeated under two light sources of different characteristics and the results are summarized below.

- 28% of the preferences gave the same results in terms of colour hue, value and chroma components under both the light source A and the light source B. Red (5R) and purple-blue (5PB), mostly yellow (5Y) are the most preferred colours.
- 38% of subjects prefer the same hue but having different value and chroma under both light sources. 72% of wall colour preferences were different under light source A and light source B.
- Green (5G) and blue-green (5BG) hue families are virtually never preferred by subjects for living room walls. Green-yellow (5GY) is the least preferred colour hue in wall colour preference.

- Gender-based preference results show that female subjects prefer high value-low chroma of red (19%), yellow (22-26%) and red-purple (15%) hues under both light sources. Male subjects preferred high value-chroma of red (15%) hue under the light source A and preferred purple-blue (25%) hues under the light source B.
- Under the light source A, subjects selected the mostly blue hue family with 21%. Blue hues preferences have fallen to 9% under light source.
- Under light source B, purple-blue (5PB) was the most preferred colour with 25%. 15% under light source A.
- Highly low chromas of 5B, 5R, 5Y and 5PB are preferred under the light source.
- Under the light source B, 5 PB, 5R and 5Y were the most preferred colours.
- The colour hues preferences generally distinguish by sex. But both gender preferred high value (light colour) and low chroma of colour hues.

The results show that although subjects have similar preferences under A and B light source but there are differences in colour perception. Findings from this survey revealed that subjects were affected by the colour characteristics of the light source and discriminated according to sex. Such and similar studies will contribute to obtaining more objective results in terms of environment-human interaction and colour preferences.

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Experimental Investigation into the Mediating Variables of the Relationship Between Colour Focality and Colour Preference

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ABSTRACT

This study attempted to clarify the continuous relationship between colour focality and aesthetic preference and the psychological variable(s) that mediates this relationship through two psychological experiments conducted in Japanese. The psychological processing fluency and 22 colour impressions were tested as candidates for the mediating variables. Experiment results show that, in modern Japan, colour focality has a negative influence on colour preference, which is mediated by the colour impression *gracefulness*. This relationship may be derived from the convention that high-focality colours are often sensed as being flashy and unpleasant in many colour-related areas in modern Japan.

Keywords: *Colour focality, colour preference, colour impression, gracefulness, Japan*

INTRODUCTION

The continuum of colour percept is parceled up into a set of basic colour categories (BCCs) in most languages, such as *black*, *white*, *red*, *green*, *yellow*, *blue*, *blown*, *pink*, *orange*, *grey,* and *purple* in the English language (Berlin and Kay, 1991). The member colours of a BCC differ in their focality—namely, their closeness to the prototype of the category or, in other words, their goodness as an example of the category (Rosch, 1973).

Martindale and Moore' (1988) study is the first to investigate the relationship between colour focality and aesthetic preference. Their experimental results showed that their subjects, most of whom were probably English speakers as they were students of the University of Maine, tended to prefer colours with high focality to those with low focality. However, the focality of Martindale and Moore's colour stimuli was a discrete variable that had only five levels. This largely impeded the investigation of the continuous pattern of the focality–preference relationship. Thus, our study defined the concept of colour focality in a continuous fashion and delved into the continuous relationship between colour focality and preference—that is, how colour preference changes gradually along the continuum of colour focality. The second aim of our study is to clarify the psychological variable(s) that mediates the relationship between colour focality and preference or, in other words, how colour focality exerts its impact on colour preference. To our knowledge, our study is the first experimental study to pursue these two purposes. In addition, our study tested the Japanese language. It is interesting to compare our results and the results of Martindale and Moore's English-testing study.

Two sorts of candidates for the mediating variables were investigated in our study. The first was the "psychological processing fluency" (PPF) of colours. Reber et al. (2004) argued that high-focality colours were more likely to be preferred than low-focality colours because the high focality of a colour could facilitate the mental processing of the colour. The other candidates were 22 colour impressions—*static–dynamic*, *ornate–plain*, *passive–active*, *noisy–quiet*, *positive–negative*, *cheerful–gloomy*, *warm–cool*, *novel–ordinary*, *light–dark*, *cruel–kind*, *beautiful–ugly*, *clean–dirty*, *pleasant–unpleasant*, *successful–unsuccessful*, *clear–dull*, *graceful–awkward*, *true–false*, *stable–changeable*, *soft–hard*, *relaxed–nervous*, *strong–weak*, and *heavy–light*—collected from literature on colour affective evaluations. We conducted two psychological experiments to measure the focality, preference, PPF, and colour impressions of our colour stimuli.

EXPERIMENTAL

Experimental Stimuli and Environment

In this study, the short-term memory (STM) accuracy of the test colours was used as the operative indicator of the PPF of the colours for two reasons: 1) generally speaking, a stimulus that can be easily processed in our minds is also easy to memorize, and 2) the STM accuracy of a stimulus reflects multiple presumably fluency-related properties of the stimulus, e.g., linguistic codability (Lucy and Shweder, 1979), visual discriminability (Brown and Lenneberg, 1954), and ecological relevance (McCarthy, 1990).

A colour chip array (Munsell Book of Colour, Glossy Edition, layout shown in Figure 1) was used in this study. The 30 colours within the bold-line-surrounded area were tested in the experiments, because they formed a large contiguous region on the array, which made them covering the entire continuum of focality, and because they could sample a large number of Japanese BCCs. The experiments were performed indoors with fluorescent lighting (type: National FHF 32EXN-H, daylight colour, colour temperature: 5000K). The distance between the stimuli and the subjects' eyes was controlled at 50 cm.

Experiment 1

Experiment 1 had two sessions. Session 1 measured the STM accuracy, which indicated the PPF of the test colours, and Session 2 quantified their focality. Details of the design and results of Experiment 1 were published in Fang and Matsui (2017).

Twenty-two subjects (11 male and 11 female, aged M = 31.45 and SD = 14.34, native Japanese speakers) who are either undergraduate or graduate students at Waseda University took part in the experiment. None reported having colour-related art experience. They all passed the Ishihara Colour Vision Test (38 plates, International Edition), and no one reported having colour-vision deficiencies.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	5BG 9/2	10BG 9/2	5B 9/2	10B 9/2	5PB 9/2	10PB 9/2	5P 9/2	10P 9/2	5RP 9/2	10RP 9/2	5R 9/2	10R 9/2	5YR 9/2	10YR 9/4	5Y 9/6	10Y 9/6	5GY 9/4	10GY 9/4	5G 9/2	10G 9/2
B	5BG 8/4	10BG 8/4	5B 8/4	10B 8/6	5PB 8/6	10PB 8/4	5P 8/4	10P 8/6	5RP 8/6	10RP 8/6	5R 8/6	10R 8/6	5YR 8/8	10YR 8/14	5Y 8/14	10Y 8/12	5GY 8/10	10GY 8/8	5G 8/6	10G 8/6
C	5BG 7/8	10BG 7/8	5B 7/8	10B 7/8	5PB 7/8	10PB 7/8	5P 7/8	10P 7/8	5RP 7/10	10RP 7/8	5R 7/10	10R 7/10	5YR 7/14	10YR 7/14	5Y 7/12	10Y 7/12	5GY 7/12	10GY 7/10	5G 7/10	10G 7/8
D	5BG 6/10	10BG 6/8	5B 6/10	10B 6/10	5PB 6/10	10PB 6/10	5P 6/8	10P 6/10	5RP 6/12	10RP 6/12	5R 6/12	10R 6/14	5YR 6/14	10YR 6/12	5Y 6/10	10Y 6/10	5GY 6/10	10GY 6/12	5G 6/10	10G 6/10
E	5BG 5/10	10BG 5/10	5B 5/10	10B 5/12	5PB 5/12	10PB 5/10	5P 5/10	10P 5/12	5RP 5/12	10RP 5/14	5R 5/14	10R 5/16	5YR 5/12	10YR 5/10	5Y 5/8	10Y 5/8	5GY 5/10	10GY 5/12	5G 5/10	10G 5/10
F	5BG 4/8	10BG 4/8	5B 4/10	10B 4/10	5PB 4/12	10PB 4/12	5P 4/12	10P 4/12	5RP 4/12	10RP 4/14	5R 4/14	10R 4/12	5YR 4/8	10YR 4/8	5Y 4/6	10Y 4/6	5GY 4/8	10GY 4/8	5G 4/10	10G 4/10
G	5BG 3/8	10BG 3/8	5B 3/8	10B 3/10	5PB 3/10	10PB 3/10	5P 3/10	10P 3/10	5RP 3/10	10RP 3/10	5R 3/10	10R 3/10	5YR 3/6	10YR 3/6	5Y 3/4	10Y 3/4	5GY 3/6	10GY 3/6	5G 3/8	10G 3/8
H	5BG 2/6	10BG 2/6	5B 2/6	10B 2/6	5PB 2/8	10PB 2/10	5P 2/8	10P 2/6	5RP 2/8	10RP 2/8	5R 2/8	10R 2/6	5YR 2/4	10YR 2/2	5Y 2/2	10Y 2/2	5GY 2/2	10GY 2/4	5G 2/6	10G 2/6

Figure 1: Layout of the colour chip array with the test colours surrounded by bold lines.

Session 1 consisted of 33 trials. In each trial, a test colour was presented to the subject for 5 s and then retrieved. After 30 s, the colour array was presented, and the subject was asked to find the previously presented colour in the array. For each subject, each test colour was tested at least once and in a random order.

Session 2 first elicited the coverages of six Japanese BCCs—*akairo* [*red*], *pinkuiro* [*pink*], *kiiro* [*yellow*], *orenjiiro* [*orange*], *chairo* [*brown*], and *murasakiiro* [*purple*]—by asking the subject to report the colours that belonged to each BCC. Next, the subject was required to report the colours that were the best examples of each BCC.

Experiment 2

Experiment 2 quantified the preference and the 22 colour impressions of the test colours.
Thirty-two subjects who are either undergraduate or graduate students at Waseda University took part in the experiment. They all passed the Ishihara Colour Vision Test (38 plates, International Edition), and no one reported having colour-vision deficiencies. Three subjects were excluded from data processing because they reported having colour-related art experience. The rating data by the rest 29 subjects (14 male and 15 female, aged M = 28.41 and SD = 12.24) were used in data processing.

This experiment consisted of 30 trials. In each trial, a test colour was presented to the subject, and the subject was asked to rate the colour on 22 seven-point Likert scales that represented the 22 colour impressions and another seven-point *like–dislike* Likert scale*,* which measured the degree of preference. For each subject, each test colour was tested once and in a random order.

RESULTS AND DISCUSSION

Variable Definitions

Focality score. Using the data obtained in Section 2 of Experiment 1, we first computed the Red, Pink, Yellow, Orange, Brown, and Purple Indexes for each test colour. The Red Index of a colour was computed by dividing the number of subjects who named the colour as *akairo* [*red*] by the total number of subjects. The other five indexes were similarly defined. Since the six indexes measured the inter-subject naming consistency of a colour in terms of each BCC, we defined the focality score (FS) of a test colour as the highest of the six indexes of the colour.

Memory accuracy score. Using the data obtained in Section 1 of Experiment 1, we defined the memory accuracy score (MAS), which indicated the PPF of a test colour as the percentage of the trials in which the subjects correctly recognized the colour.

Preference score. Using the data obtained in Experiment 2, we defined the preference score (PS) of each test colour as its average rating score across subjects on the *like–dislike* Likert scale.

Colour impression scores. Using the data obtained in Experiment 2, we defined each colour impression score of a test colour as its average rating score across subjects on the corresponding colour impression scale.

Statistical Analyses and Results

Relationships between colour focality and preference. Through the regression analysis, a significant negative relationship was found between FS and gracefulness score (GS), i.e., the score on the *graceful–awkward* scale ($R = -0.584$, $P < 0.001$, plotted in Figure 2[a]). No other colour impression score showed any significant relationship with FS.

Relationship between colour impressions and preference. We found a significant positive relationship between GS and PS through regression analysis ($R = 0.623$, $P < 0.001$, plotted in Figure 2[b]). Because GS has a significant relationship with both FS and PS, it is reasonable to argue that GS bridges FS and PS. Regarding other colour impression scores, heaviness ($R = -0.439$, $P = 0.015$), lightness ($R = 0.555$, $P = 0.001$), noisiness ($R = 0.509$, $P = 0.004$), ornateness ($R = 0.668$, $P < 0.001$), pleasantness ($R = 0.910$, $P < 0.001$), cleanness ($R = 0.673$, $P < 0.001$), cheerfulness ($R = 0.630$, $P < 0.001$), clearness ($R = 0.673$, $P < 0.001$), dynamism ($R = 0.507$, $P = 0.004$), trueness ($R = 0.793$, $P < 0.001$), novelty ($R = 0.581$, $P < 0.001$), beauty ($R = 0.922$, $P < 0.001$), successfulness ($R = 0.818$, $P < 0.001$), positivity ($R = 0.657$, $P < 0.001$), and activity ($R = 0.549$, $P = 0.002$) scores also had significant linear relationships with PS. However, because these scores do not have a significant relationship with FS, it is impossible for them to bridge FS and PS.

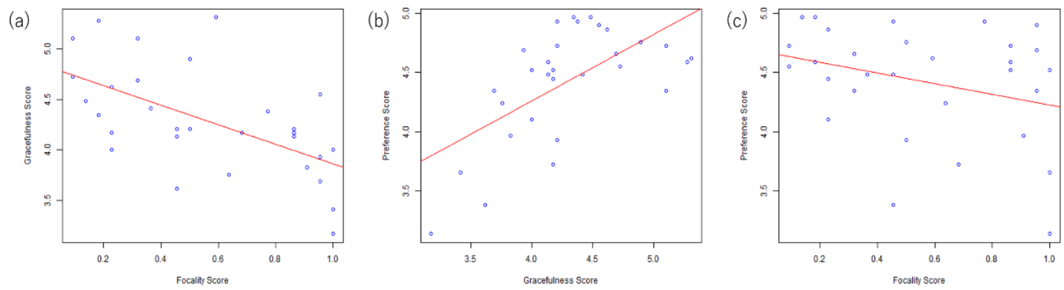

Figure 2: Plots of the (a) FS-GS, (b) GS-PS, and (c) FS-PS relationships with the regression lines displayed in red.

Relationship between colour focality and PPF. Through the regression analysis, we found a significant U-shaped quadratic relationship ($R^2 = 0.233$, $P = 0.028$ [$B_{FS} = -0.893$, $P = 0.037$; $B_{FS*FS} = 0.885$, $P = 0.018$]) between FS and PS but not a significant linear one.

Relationship between PPF and preference of colours. No significant linear or quadratic regression model was found between MAS and PS (linear regression model: $R^2 = 0.001$, $P = 0.845$; quadratic regression model: $R^2 = 0.042$, $P = 0.562$).

Relationship between colour focality and preference. We plotted the FSs and PSs of the test colours as shown in Figure 2[c] and discerned a descending trend in the plot. Yet, the result of the linear regression analysis did not achieve statistical significance ($R = -0.300$, $P = 0.108$). This seems counterintuitive since both FS and PS have a significant linear relationship with GS. A possible cause of this result is discussed later.

Discussion

The experimental finding of a negative linear relationship between FS and GS and a positive linear relationship between GS and PS indicate that colour focality has a negative influence on colour focality, which is mediated by the evaluation of the colour impression *gracefulness*. Because both FS–GS and GS–PS relationships have an *R* larger than 0.50, it is reasonable to argue that a linear relationship really exists between FS and PS. However, probably because the FS–PS relationship contained noises in both the FS–GS and GS–PS data, the FS–PS linear regression model did not reach statistical significance. This interpretation also fits Leder et al.'s (2004) psychological model of aesthetics, as focality is located in the perceptual analyses stage and *gracefulness* is likely situated in the implicit memory integration stage with preference being the final output.

Concerning PPF, its role as a mediating variable between colour focality and preference is not supported in this study because, despite the discovery of a significant quadratic relationship between MAS and FS, no significant MAS–PS relationship was found. Even if PPF really mediates between colour focality and preference, the effect might be too small compared to that of the colour impression *gracefulness*. In addition, no colour impression scores other than GS were found to possess significant relationships with FS. Hence, the colour impression *gracefulness* was the only psychological variable detected in this study as mediating between colour focality and preference.

We speculate that this focality–gracefulness–preference relationship derived from the convention that high-focality colours are generally felt as flashy and gaudy and, therefore, unpleasant. This convention can be observed in various colour-related areas, e.g., city planning (Mitsuboshi, 2011) and apparel design (Murayama, 2016), in modern Japan.

CONCLUSION

This study found that, in modern Japanese culture, colour focality has a negative impact on colour preference, which is mediated by colour impression *gracefulness*. However, as high-focality colours are popular in places such as the U.S. (Martindale and Moore, 1988) and China (Murayama 2016), the focality–preference relationship of colours and its mediating variables likely vary across cultures.

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Emotions, colour and space

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ABSTRACT

In this work, we will present the influence of a monochromatic space in the meanings of colour and the emotions through a quasi-experimental study where people will be placed in a luminous monochromatic space.

Objective: To know the influence of a monochromatic space in the emotions and its relation with the meaning of the colours.

We will briefly present the theoretical basis of emotions and its difference with the feelings, as well as the influence that colours have on them using a mixed method in a college population.

The results indicate that there is a relationship between colours and emotions and that monochromatic spaces have an influence on this relationship.

Keywords: *emotion, feeling, colour, space*

INTRODUCTION

Those who study emotion and feelings face the problem of dissociating both terms from a scientific point of view, because they do not have a consensus either in their definition nor their classification, although all coincide that emotions are of short duration and have a physiological burden, where neurotransmitters and different basic systems are involved in the process of escape or permanence when facing danger, and the feelings are a state or change of mood influenced by the social context. Both play an important role in decision making.

Bisquerra Alzina (2003) gives us a wide although no conclusive definition: "an emotion is a complex state of the organism characterized by an excitation or perturbation that predisposes to action" (page 11).

The positive/negative classification is the result of a favorable or not favorable assessment of an event with respect to the objectives themselves.

The emotions/feelings found based on positive/negative are:

- Negative emotions such as fear, anger, anxiety, sadness, guilt, shame, envy, jealousy, disgust, among others.
- Positive emotions/feelings are joy, love, affection, relief, happiness, being proud.

In the field of Psychology, one aspect of colour that has caused various controversies is the influence of colour on emotions due to its repercussions on human behavior. The relationship between emotion and colour is based on nature and its effects and on the meanings of the colours. For this reason, it is necessary to study the meaning of the colours and their correlation with the emotion/feeling, which in turn the latter seem to be indivisible (Ortiz: 2011 (Bizquerra Alzina, 2003)).

RESEARCH

This research is focused on knowing if a monochromatic environment modifies the emotions/feelings and meanings of colours knowing in advance that there are many factors that are influencing people before, during and after the experiment. We started from the fact that a monochromatic environment is never found in a natural environment and that will strongly affect the emotions/feelings of the people exposed, as well as the meaning they have for each colour.

Another premise was that one of the ways of knowing the thoughts, emotions/feelings, and meanings, is through the words that form the verbal or written language, since they are the ones that help us to understand the interior of each person, so in this investigation the words that qualify the emotions/feelings and the meanings before and after being exposed to a single colour were used.

This research is based on the following question:

Does a monochromatic light environment influence emotions/feelings in the meaning of colours?

General objective

To know if staying in an environment of monochromatic light has an influence on the emotions/feelings and the meanings of colour.

Methodology: mixed.

Research design: Exploratory, quasi-experimental, cross-sectional study

Variables: Dependent: emotions / feelings expressed, Meaning of colours. Independent: Monochromatic space with the colours red, blue, green, yellow, pink, white and black

Instrument: A questionnaire that consists of the following parts: General data; List of colours to which three meanings must be added; List of emotions/feelings to which three colours should be added.

Procedure

- The subject receives an instrument to answer.
- The subject, wearing a white coat to avoid colour interference, goes to a 2.91 m by 1.36 m room, fully illuminated with LED lights of the colours red (R = 255; G = 000; B = 000), pink (R = 255; G = 000; B = 009), yellow (R = 255, G = 060, B = 000), green (R = 000, G =

255, B = 000), blue (R = 000, G = 000, B = 255) and achromatic, white (R = 255; G = 255; B = 255) and black (R = 000; G = 000; B = 000).

- The order of exposure to the chromatic stimuli was randomly chosen, during a period of 5 minutes

RESULTS

General data

The sample consisted of 20 subjects, 60% were women and 40% were men. The mean age was 26.45 years; 60% described themselves as extroverted and 40% as introverted; 85% were single and 15% were married or in an unmarried union; 45% of them were working and 55% were students.

Meaning of the colours after and before the test

The colours/emotions relationship is known through the relationship between meanings/colours, so we applied a pre-test, a list of colours to which the subjects had to put meanings. After that, the subject was placed in a luminous monochromatic environment and subsequently, we applied the list of colours (post-test) again.

The results indicate that the exposure to different monochromatic spaces influenced the number of meanings, generating a greater number of meanings after the test.

Once we knew and compared the meanings, we selected those related to the emotions/feelings. We compared them with the non-emotional meanings and we found significant differences x2 = 45.42 p <0.001 between the results before and after the test (Graph 1). However, we found changes in both groups before and after the monochromatic luminous stimulus.

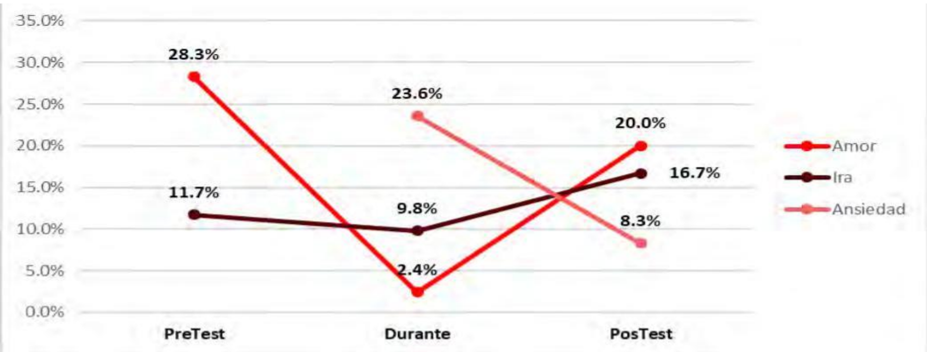
Subsequently, the emotions were classified into positive and negative and compared, finding a correlation of X2=20 p<0.0001, which shows differences between the positive emotional content before and after the experiment (Graph 2). As in the previous analysis, we found that there were important changes in both groups (positive and negative) before and after the test.

Effect of the monochromatic space in the emotions and feelings

By relating the emotions in the three stages of the research, we obtained that:

The emotions/sensations that people expressed after the exposure to red were anger and anxiety, sadness, joy and memories of love. The main sensation with a total luminous stimulation was anxiety (graph 1).

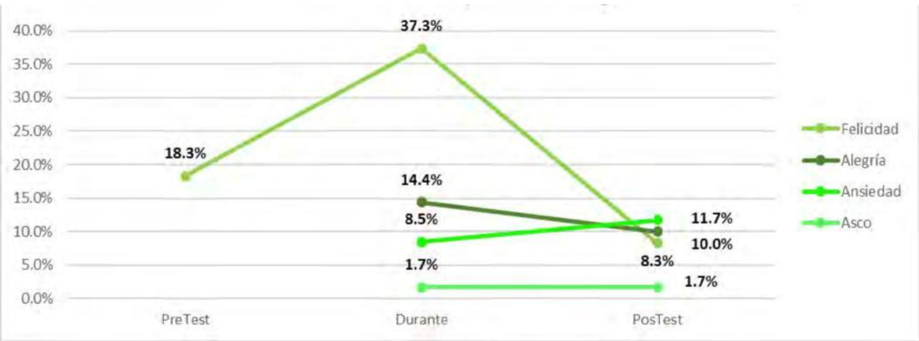
Graph 1. Association of Red colour (anger/anxiety/love)



Personal elaboration.

The emotions/feelings generated by green were mainly happiness and joy; however, some people felt anxiety and two disgust when being exposed to monochromatic green (Graph 2).

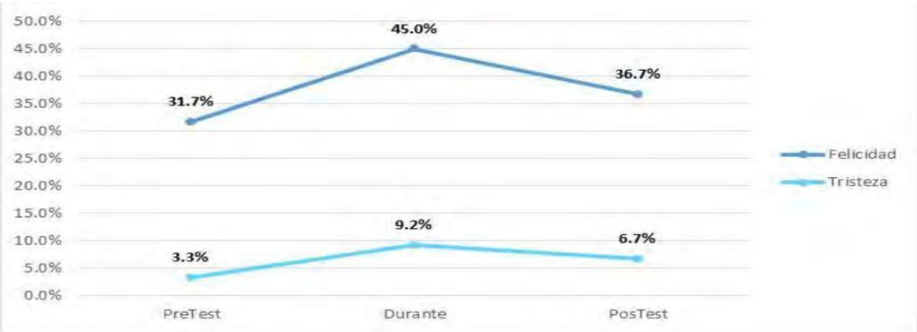
Graph 2. Association of Green colour (happiness/joy/anxiety/disgust)



Personal elaboration.

We found that most people felt happiness with the blue luminous stimulus (graph 3), but for a few, it caused sadness, so, blue has an ambivalent effect.

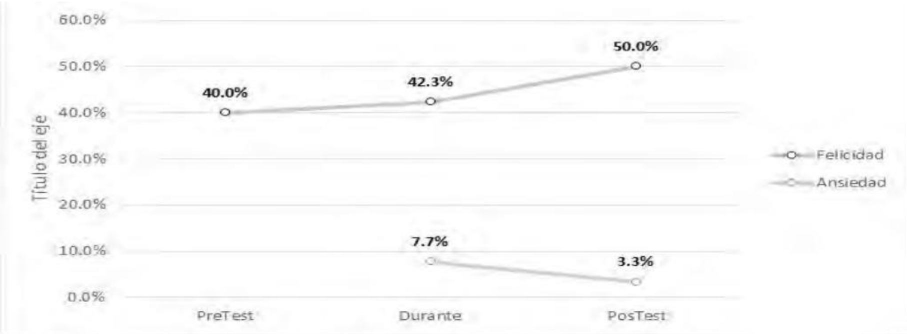
Graph 3. Association of blue colour (happiness/sadness)



Personal elaboration.

For white (graph 4), such as with blue the concept of happiness was dominant and then sadness and anxiety appeared.

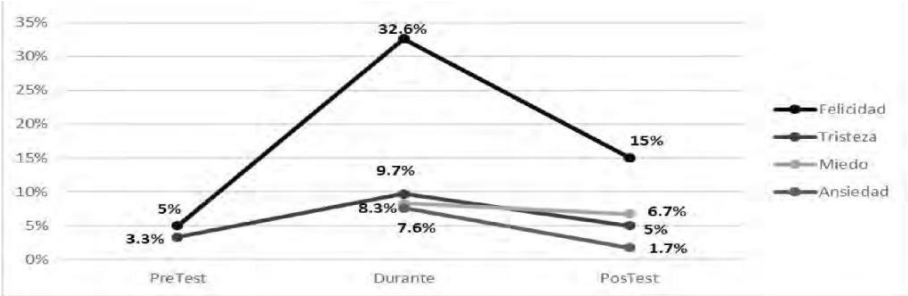
Graph 3. Association of white colour (happiness/anxiety)



Personal elaboration.

The ambivalence found for blue and white appears again with black as it was related to happiness although black is mainly related to negative emotions in different kinds of research.

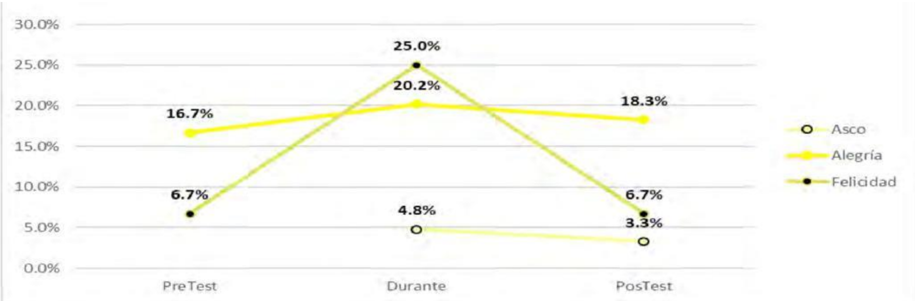
Graph 4. Association of black colour (joy/sadness/fear/anxiety)



Personal elaboration.

Happiness was the most frequent answer before the test, but during the experiment it caused joy.

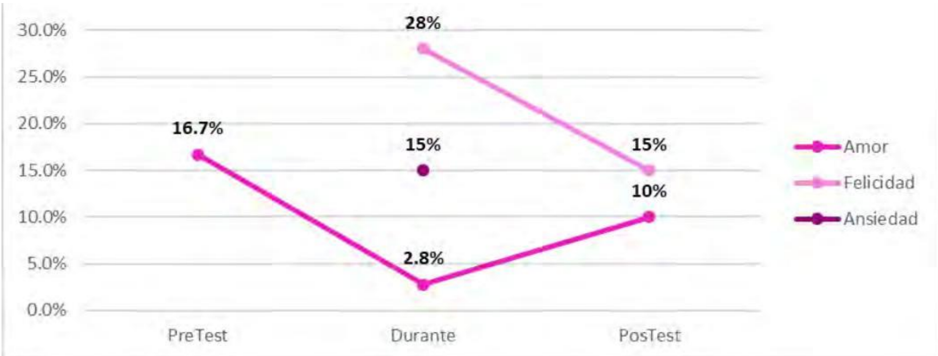
Graph 5. Association of Yellow colour (happiness/joy/disgust)



Personal elaboration.

Pink was associated with love; however, the monochromatic space generated an experience of happiness and anxiety.

Graph 6. Association of pink colour (love/joy/anxiety)



Personal elaboration.

CONCLUSION

Colour represent an important factor in people's perception of the world since it directs the way they experience the environment. In this research, we found that exposure to a monochromatic space redefines the cultural concepts we may have of colours, adding new definitions associated with them, which, in particular, are of an emotional nature.

Although there are no monochromatic spaces in the natural environment, being exposed to one, even for a brief period of time, influences mood and emotions, so it is necessary to carry out more research to know the extent of influence and its relationship with behaviour.

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Categories on a colour plane constituted by Yellow-blue and Lightness in Dichromats

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ABSTRACT

A new method of a colour universal design is proposed. In the new method, designers determine colour arrangements in a colour plane constituted by yellow-blue and lightness that dichromats perceive, and then they can change each colour along each dichromatic confusion colour line. To establish the method, in this study we investigated what colour category was usable to design colour arrangements in the colour plane constituted by yellow-blue and lightness. The stimuli were 90 colour patches arranged with yellow-blue as a horizontal axis and lightness as a vertical axis. Participants were asked to draw boundaries of category and to mark a representative colour in each colour category. The results showed that dichromats could divide the colour plane into at least seven categories. It was revealed that the colour categories usable to design a colour arrangement in the colour plane were yellow, dark yellow, darker yellow, grey, black, blue, and dark blue.

Keywords: *Colour deficiency, Dichromat, Colour universal design, Colour category, Colour arrangement*

INTRODUCTION

Colour vision is diverse, and includes protanopia and deuteranopia. Recently, a system for universal colour design has been proposed that enables dichromats to understand colour information in visual display materials. Generally, in universal colour design, designers first determine colour arrangements that are appropriate for normal trichromats. Next, they confirm whether dichromats can discriminate the colours by simulating the colour appearance experienced by dichromats. Then, if the colour arrangements are difficult for dichromats to discriminate, the colour arrangements are adjusted and the process is repeated. Thus, the procedure requires a degree of trial and error to determine colour arrangements. To address this, Sato (2005) and Oide et al. (2016) proposed a new universal colour design method. In the new method, designers first determine colour arrangements in a colour plane constituted by yellow-blue and lightness that dichromats are able to perceive. Next, they change each colour along each confusion colour line. Even though the colours have been modified, dichromats perceive the colours as unchanged. Thus, the colour appearance of the stimuli is preserved for dichromats.

This method is complicated by the reality that protanopic confusion lines and deutranopic confusion lines do not agree. To address this, Oide et al. (2016) proposed the introduction of acceptable colour shifts within a consistent colour category that is appropriate for dichromats. In this study, we sought to clarify acceptable colour shifts by measuring colour categories in the colour plane constituted by yellow-blue and lightness for dichromats and trichromats.

METHODS

Participants

Participants included 12 normal trichromats, 3 protanopes, and 6 deuteranopes. We screened and classified the colour vision of the participants according to their performance on the Ishihara plates, the Panel D-15 test, the Farnsworth-Munsell 100-Hue test, and the Neitz anomaloscope.

Apparatus

We used a LCD display (ColourEdge CX241, Eizo) in a darkroom to present the stimuli. D65 fluorescent lights (Toshiba FL20S·D-EL-D65, measured CCT: T_{cp} = 6206 K, d_{uv} = 0.0035) were positioned over the observer's head so that they could perform tasks in the darkroom. We shaded the light to prevent it from shining directly on the display.

Stimuli

As shown in Figure 1, the stimuli were 90 colour patches positioned on a yellow-blue spectrum with dominant wavelengths of 575 nm and 475 nm, respectively, as a horizontal axis, and lightness as a vertical axis. Assuming the perfect reflecting diffuser was 240 cd/m^2, the Munsell values of the colour patches ranged from V = 1/ to V = 9/. The Munsell chromas of the colour patches ranged from C = /0 (minimum) and C = /16 (maximum) with every 2-chroma interval. The background colour was white (N 9.5) with a luminance of 210.6 cd/m^2. The size of the colour patch was 1.5 degrees in visual angle.

Figure 1: Stimuli.

Procedure.

Participants were asked to draw boundaries to divide the colour plane into the instructed number of colour categories and to mark a representative colour for each colour category on a sheet of paper. When drawing boundaries, participants were asked to think of the colours on a railway map as an example of visual display material with divided colour categories. A representative colour was defined as a colour patch that characterized the colour category. The number of colour categories started at 2 and increased to a maximum point, which was the point at which the participants stated that it was too difficult to discriminate the colour arrangement of the visual display materials. The experiment was performed three times for each participant.

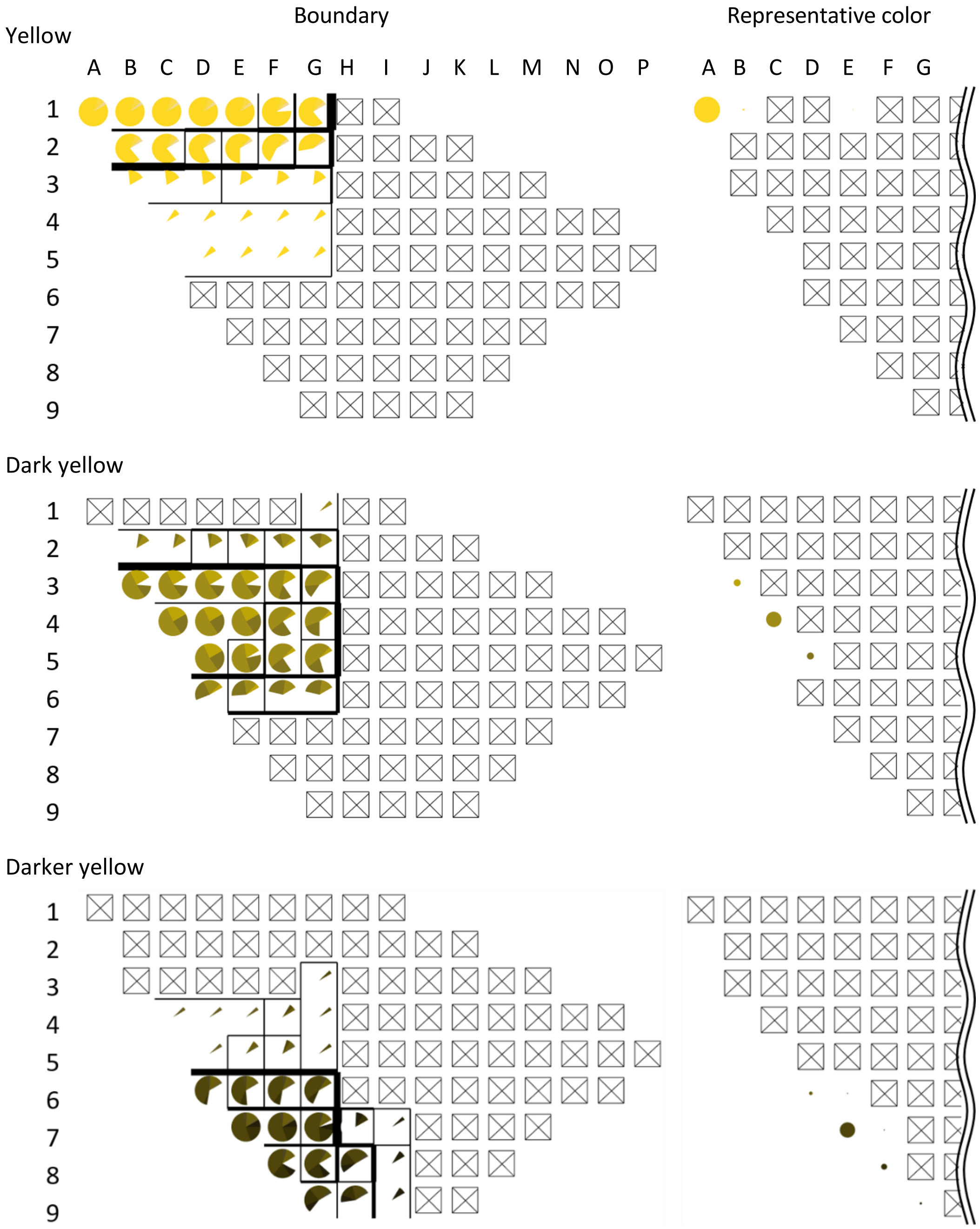

Figure 2-1: Seven color categories produced by dichromats (Yellow, Dark yellow, and Darker yellow).

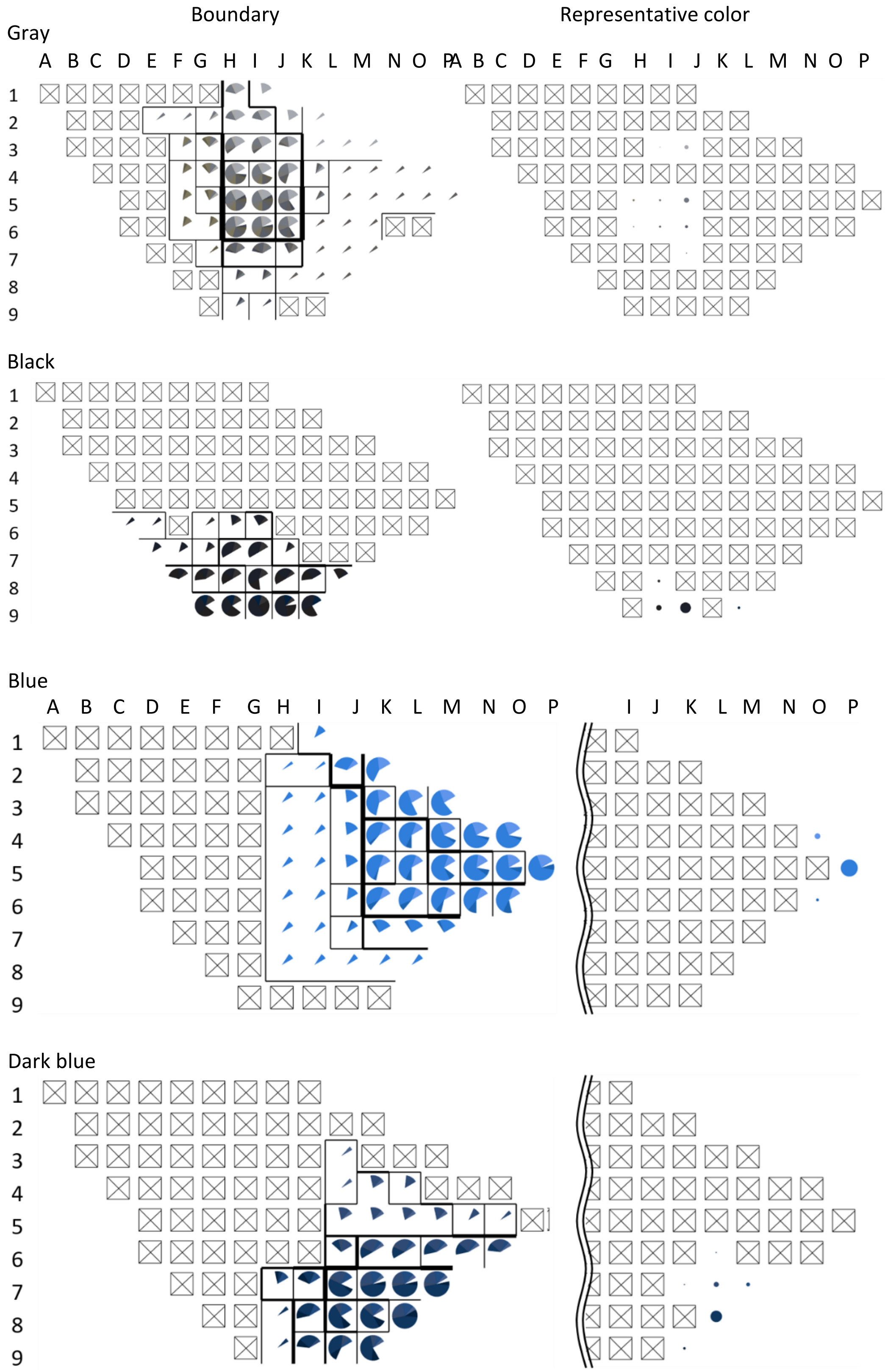

Figure 2-2: Seven color categories produced by dichromats (Gray, Black, Blue, and Dark blue).

RESULTS AND DISCUSSION

The highest maximum number of colour categories that dichromats could generate was 11, and the lowest was 7. In trichromats, the highest maximum was 13 and the lowest was 5. The average number of colour categories in dichromats was 8.78 and that of trichromats was 7.97. These results showed that dichromats tended to divide relatively more colour categories compared with trichromats. As dichromats experience a more reduced colour space, they may be more sensitive to colour differences in colour spaces that they can perceive compared with normal trichromats.

Our results indicate that dichromats could divide the colour plane into at least seven categories. We considered categories with similar characteristics to be identical colours and named the colour categories. The colour categories that dichromats selected most frequently were, in order of descending prevalence, yellow, blue, darker yellow, dark yellow, gray, dark blue, and black. This mostly corresponded to that of normal trichromats. These results of dichromats are shown in Figure 2. The horizontal and vertical axis of each figure corresponds with that of Figure 1. In the boundary region, the circle graphs on the coordinates show the proportion of the colour that dichromats selected as a colour category for each colour category. In addition, black lines show the boundaries drawn and the line thickness. In the section showing the representative colour, the circles show the coordinates of the colour patch selected as the representative colour. The size of the circle represents the number of participants who selected that colour as the representative colour.

CONCLUSION

The colour categories that can be used to design a colour arrangement in a colour plane constituted by yellow-blue and lightness were yellow, dark yellow, darker yellow, gray, black, blue, and dark blue.

ACKNOWLEDGEMENTS

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Comparison of Preferences and Impressions among Interior Images, Colour-simulated Interior Model Images, and Colour-simulated Abstract Figure Images

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ABSTRACT

This study aims to clarify differences in preferences and other impressions on three abstraction levels for interior images: interior images, plain interior model images, and abstract figure images. Three experiments in which the participants rated the impressions including preferences of the displayed images was conducted.

Following are the main results from the analyses of data obtained from the three experiments:

(1)Four factors—"brightness and cuteness," "calm and simplicity," "elegance," and "country style"—were obtained from the factor analysis of interior image impression ratings.

(2) The correlation coefficients were less than 0.46 in the comparison of preferences from the three experiments.

(3) The interior model images preferred over room interior images contained many similar hues in colour combinations.

Keywords: *Interior, Preference, Impression, Colour combination*

INTRODUCTION

Empirical studies regarding colour harmony theories or colour combination preferences have been based primarily on the harmony or preference data of colour-simulated abstract figures. However, this kind of survey does not automatically provide direct knowledge for adapting to concrete design objects, such as buildings, furniture, clothes, and so on. Commonalities and the differences between them should be confirmed.

This study aims to clarify differences in preferences and other impressions on three abstraction levels for interior images: interior images, plain interior model images, and abstract figure images.

THEORY

Kobayashi, S. proposed a map consisted of two axes "warm – cool" and "hard – soft" to express the relationship between colours or colour combinations and their impressions at 1981. This map has been used to assist colour design.

EXPERIMENTAL

(1) First experiment

It was executed to search interior images on the Web using 22 words expressing impressions of interiors at first. In the first experiment, impressions of 240 images that were selected from 660 gathered interior images were rated by 20 female university students with using six bipolar and 14 unipolar semantic scales that included preferences and the 22 words used for image searching.

(2) Second experiment

In the next step, 240 interior model images (colour-simulated using five representative colours from the images used in the first experiment) were rated by 20 female university students. Each respondent used the same scales as those in the first experiment.

(3) Third experiment

In this experiment, 240 abstract figure images having the same colour combinations as the images used in the second experiment were rated by eight female university students. The scales were the same as those in the first experiment.

(1) First experiment (2) Second experiment (3) Third experiment

Figure 1: Samples of the displayed images in each experiment

RESULTS AND DISCUSSION

(1) Factor Analysis

Factor analysis was applied to the data obtained from the first experiment after dividing the bipolar scale scores into two unipolar scores. Four factors—"brightness and cuteness," "calm and simplicity," "elegance," and "country style"—were obtained based on the condition that eigenvalues were greater than 1.0.

"Bright," "Dark," and "Cool" have large loadings on factor 1; "Calm," "Colourful," and "Pop" have large loadings on factor 2; "Elegant," "Classic," and "Western style" have large loadings on factor 3; and "Country style" have large loadings on factor 4. These facts suggest that the former two factors were largely influenced by colours while the latter two factors were largely influenced by the style or condition of the interior. [Table 1]

Rating scale	Factor 1	Factor 2	Factor 3	Factor 4	Communality
Dark	0.90	-0.05	0.09	-0.08	0.83
Dandy	0.84	0.10	0.03	-0.11	0.72
Lovely	-0.81	-0.30	0.05	0.14	0.77
Bright	-0.76	-0.15	-0.09	-0.12	0.63
Cool (2)	0.75	0.26	-0.12	-0.45	0.86
Cool	0.70	0.13	0.05	-0.55	0.81
Warm	-0.57	-0.28	-0.10	0.20	0.45
Calm	0.28	0.84	-0.22	0.28	0.91
Simple	0.24	0.84	-0.28	-0.19	0.88
Colorful	-0.55	-0.72	-0.23	-0.21	0.91
Pop	-0.59	-0.68	-0.27	-0.15	0.90
Somber	0.60	0.69	-0.19	0.11	0.89
Sophisticated	0.45	0.64	0.12	-0.43	0.82
Loud	-0.35	-0.70	0.02	-0.27	0.69
Natural	-0.19	0.68	-0.37	0.53	0.91
Refreshing	-0.29	0.64	-0.31	-0.17	0.63
Elegant	0.11	0.00	0.88	-0.23	0.85
Modern	0.03	0.13	-0.86	-0.27	0.83
Graceful	0.22	0.25	0.84	-0.17	0.84
Classic	0.10	-0.14	0.81	0.02	0.69
Western style	-0.22	-0.46	0.72	-0.16	0.80
Casual	-0.19	0.28	-0.60	0.62	0.86
Country style	-0.16	0.18	-0.06	0.82	0.74
Japanese style	0.18	0.38	-0.46	0.12	0.40
Factor contribution	25%	23%	19%	11%	78%

Cool is “Tsumetai” in Japanese, the opposite word of warm.
Cool (2) is “kakkoii” in Japanese, the opposite word of uncool.

Table 1: Result of factor analysis using data from the first experiment

(2) Regression Analysis

Regression analysis using factor scores as explanatory variables was applied to estimate preference scores [Table 2]. The multiple correlation co-efficient was 0.73.

All factors related to the preferences (p-values are smaller than 0.001); brighter and cuter, calmer and simpler, less elegant and modern, and country style rooms were preffered. The second factor, “calm and simplicity” exhibited the greatest relation based on the results of a regression analysis, whereby its effect was more than three times that of the other three factors.

The correlation coefficients upon comparing preferences from the three experiments were found to be less than 0.5 (0.34, 0.22, and 0.46) [Table 3]. This result points to the difficulty in examining the effects of an interior colour design based on knowledge regarding abstract colour design.

Parameter	Parameter estimate	Standard error of the mean	t-ratio	p-value (Prob>|t|)
Constant	4.34	0.03	147.21	<.0001
Factor 1	-0.12	0.03	-4.10	<.0001
Factor 2	0.68	0.03	22.47	<.0001
Factor 3	-0.22	0.03	-7.26	<.0001
Factor 4	0.21	0.03	6.82	<.0001

Table 2: Result of regression analysis estimating the relationship between preference scores and four factor scores

		Rating scales																			
		Color-ful	Pop	Loud / Sombe r	Warm / Cool	Bright / Dark	Calm	Dandy	Cool (2)	Simple	Refres hing	Lovely	Sophis ticated	Natura l	Coun-try style	Weste rn style / Japane se style	Casual	Prefer able / Not prefer able	Elegan t	Grace-ful	Classic / Moder n
Correa tion Coeffic ient	Room and Model	0.74	0.69	0.67	0.64	0.60	0.54	0.56	0.55	0.53	0.50	0.48	0.45	0.46	0.41	0.31	0.39	0.34	0.29	0.27	0.10
	Room and Abstract	0.69	0.66	0.61	0.62	0.50	0.51	0.55	0.52	0.45	0.44	0.42	0.46	0.34	0.39	0.28	0.33	0.22	0.17	0.10	0.13
	Model and Abstract	0.82	0.79	0.80	0.79	0.77	0.71	0.66	0.68	0.68	0.70	0.68	0.62	0.70	0.59	0.58	0.38	0.46	0.38	0.32	0.00

Table 3: Correlation coefficients among three experiments on each scale

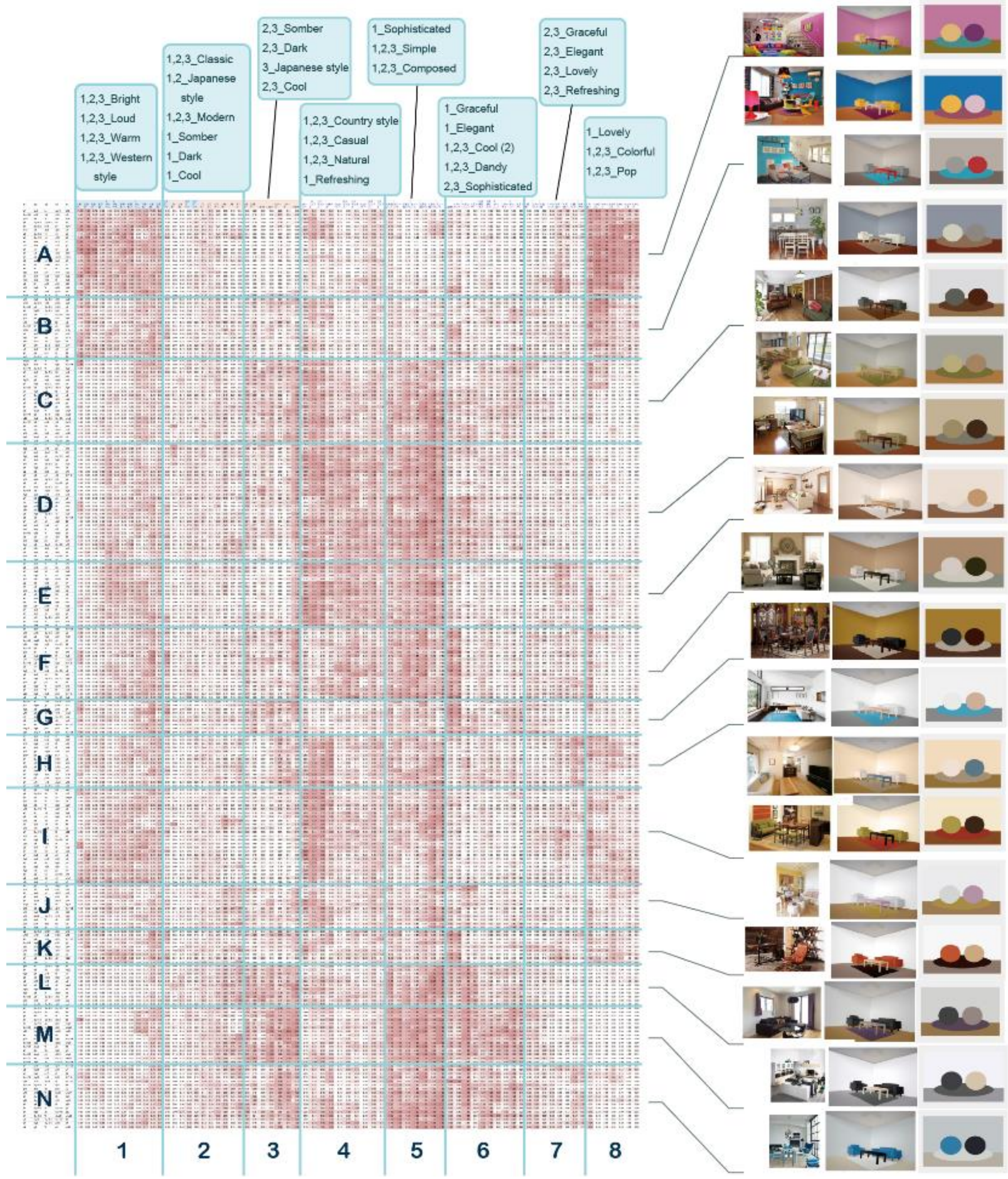

Figure 2: Ratings of three experiments with sample images (the positions are based on the results of cluster analysis)

(3) Cluster analysis

Cluster analysis of a dataset of 240 colour combinations using 66 scales (22 unipolar scales of three experiments) was executed [Figure 1]. The depth of red in figure 1 expresses score ratings on each scale. The horizontal lines divide colour combinations into 14 clusters and the vertical lines divide scales into 8 clusters.

In the three main clusters of colour combinations, A and B consisted of various hues and high saturated colours that evoked bright, cute, and colourful feelings. C to K mainly consisted of low saturated colours, whereby C to G consisted of warm colours that evoked a natural, casual, simple, and calm feeling. H to K, which had brighter walls compared to C to G and various hues or more saturated colours, evoked a casual, natural, calm, and simple feeling towards the interior images. L to N consisted of unsaturated or cool colours that evoked somber, dark, and calm feelings. These three types of colour combination might be the main interior colour combination categories in Japan.

The “1,2,3” in figure 2 means that the same scales in the three experiments appeared in the same cluster. Should the three scales be divided into two clusters, 1 would belong to a different cluster from 2 and 3. Such scales as “sombre,” “dark,” “cool,” “refreshing,” “graceful,” “elegant,” and “cute” might be influenced by the difference in coloured area size or the style factors.

(4) Comparison of the ratings of the three experiments

The small correlation between room model image ratings and abstract image ratings in table 3 could not be explained from the viewpoint of the style or style. Further analysis is therefore necessary.

Figure 3 expresses the preference rating differences among three experiments. The model interior images situated on the left part of figure 3 and preferred over room interior images contained many similar hues in colour combinations. This suggests a higher allowance of saturated or different hue colour furnishings of room colours in the real room interior compared to the interior model. The interior model images preferred over abstract images situated on the upper part of figure 3 consist of many unclear colours such as grey and beige. The natural contrasting of bright and dark parts in interior model images might raise the ratings.

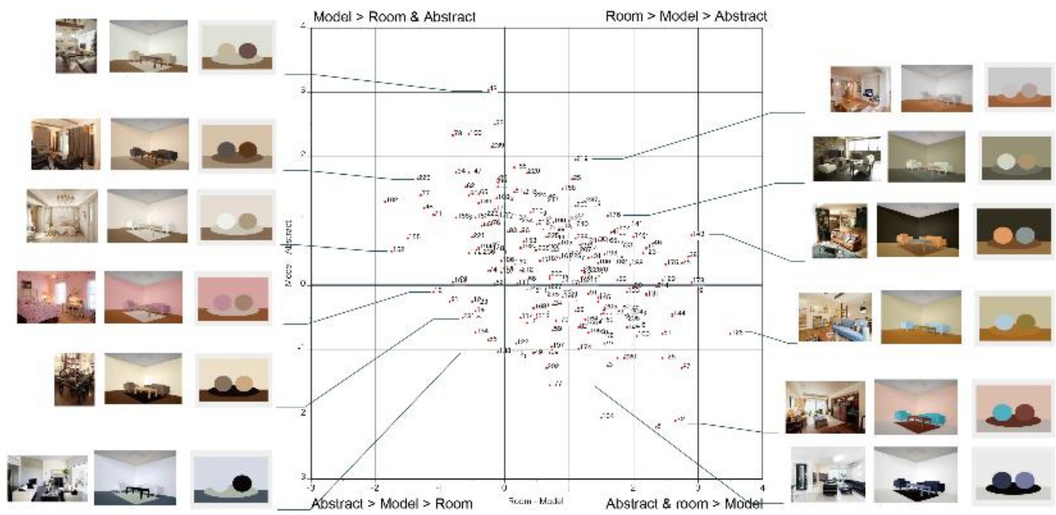

Figure 3: The images that have large differences between three experiments

CONCLUSION

Ratings of abstract colour combination images only have a small correlation to the evaluation of room interior and interior model colour combination images. A colour harmony theory for abstract colour combination is difficult to apply to room interior. Simulation on each case would be necessary to realize better colour scheme.

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Indications for a Valid Colour Test to Measure Personality, Visual Needs and Preferences for Tailored Design Applications

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ABSTRACT

This study examines the validity of a simple colour test, which could provide rapid insight into the design preferences of customers. The colour test framework is based on the 3-dimensional bipolar Genetic Semantics theory, filled up with the three fundamental neural dimensions that underlie colour coding in the human visual system, supplemented with the three basic dimensions of colour experience. The sample comprises 173 Belgian citizens. Significant and theoretically congruent influences are observed between the Five-Factor personality dimensions and the six bipolar colour choices. Moreover, interconnections among the six colour questions confirm the used dimensional framework. The present colour test actually does provide information about someone's personality. The overall results promise to have great relevance to designers.

Keywords: *colour test, genetics, personality, preferences, design*

INTRODUCTION

For to design tailor-made products and spaces, with positive identification and client well-being as a result, designers increasingly want to gain insight into their customers' personal preferences. Today, this happens through time-consuming conversations, mood boards or home visits. As designers are insufficiently psychologically skilled, the correct conclusion is not guaranteed. To accommodate the problem, the present study examines the validity of a simple colour test, which could, on the basis of the resulting personality information, provide insight into the design preferences of customers.

THEORY

The basic assumption for the construction of the colour test is that personality traits and colour preferences are largely inherited. Substantial heritable components explain up to 60% of the variance of personality traits (Lo et al., 2016; Power & Pluess, 2015). Granger (2010) states that colour preference in man is innately determined and little influenced by environmental or educational experiences. To fit in closely with this biologic-genetic aspect, the 3-dimensional bipolar model of the Genetic Semantic theory (Michiels & Alpaerts, 2018) is chosen as the framework for the colour test, filled up with contrasting colour parameters derived from two sources.

The first source is the opponent colour system from the retinal ganglion cells, consisting of 'blue–yellow', 'red-green' and 'black-white' contrast components. These three fundamental neural dimensions underlie colour coding in the human visual system and transmit visual information from the retina to several regions in the brain. The second source comes from colour experience with its three basic dimensions: Hue ('cold-warm'), Lightness ('dark-light') and Saturation ('gray-coloured'), presented as colour palettes. This way shaping the present colour test, consisting of 2 x 3 bipolar questions (Table 1) arranged in subsequent steps according to the Genetic Semantic guidelines. The six colour steps are dichotomous 0–1 items (no/yes).

COLOR			PALETTE		
STEP	0	1	STEP	0	1
1	Blue	Yellow	4	Cold	Warm
2	Black	White	5	Dark	Light
3	Green	Red	6	gray	Colored

Table 1: The six steps of bipolar choice in the colour test.

The values for the colours in step 1 and 3 are derived from mean nm calculations from cross-cultural research results of unique hues, 'unique' meaning that the hue does not contain any of the other hues. Following NCS (Natural Colour System) values were selected: blue NCS 3060-R90B, green NCS 1070-G10Y, yellow NCS 0580-Y, red NCS 1085-Y90R supplemented with white NCS 0300-N and black NCS 9000-N.

Because the widely used and empirically tested Five-Factor model of personality (BIG FIVE) (Costa & McCrae,1992) summarizes and integrates the majority of personality traits and show to be more or less distinct features (McCrae & Costa, 1997; Saucier & Goldberg, 1996), this model is used to measure personality. The NEO-FFI inventory, comprising 20 items, provides a measurement of Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness, each made up of 4 items scored using a five-point Likert scale from 1 ('strongly disagree') to 5 ('strongly agree').

EXPERIMENTAL

The participants were a random sample of 173 Belgian citizens within an age range of 18 to 89 years (Mean 45,71) with a diverse cultural background, social status and education, of which 56% women. Eight students from Antwerp University (UA) administered the interviews at the participants' homes. None of the participants had red-green colour vision deficiency as assessed through a printed Ishihara test. The material consisted of 12 glossy colour cards (10 cm2 each) presented in pairs in fixed order from step 1 to 6 (Table 1), and a pencil and paper version of the NEO-FFI-20-item questionnaire. The paired colour cards of the test were consequently shown under a standard LED illuminant 75 WATT with a colour temperature of 2700K placed at 40 cm distance from the cards. The data was collected by a UA student and inserted into SPSS. The data analysis was performed by the author.

RESULTS AND DISCUSSION

To examine the significant links between the colour choices in the six steps and the BIG FIVE traits, Independent Sample *t* Tests are performed. Table 2 shows the best scoring *p* and *t* values of the equality of means, of which the black fields with $p < 0.05$.

STEP	PAIR	EX.		OP.		CO.		AG.		NE.	
		t	*p*	*t*	*p*	*t*	*p*	*t*	*p*	*t*	*p*
1	**BL/YL**	**-2,27**	**,02**	-,72	,47	-,95	,34	,13	,90	-,23	,82
2	**BK/WH**	-,83	,41	1,14	,26	**-2,35**	**,02**	-1,36	,18	1,31	,19
3	**GR/RD**	,10	,92	1,39	,17	**-1,54**	**,13**	-,61	,54	**-1,45**	**,15**
4	**Cl/Wa**	**-2,41**	**,02**	**-3,07**	**,00**	,39	,69	,68	,49	-,23	,82
5	**Da/Li**	,89	,37	-,39	,70	-,92	,36	**1,57**	**,18**	-,83	,41
6	**Gr/Co**	-,44	,66	**1,79**	**,07**	,02	,98	-1,45	,15	**-1,54**	**,12**

n 173, Abbreviations: BL:blue, YL:yellow, BK:black, WH:white, GR:green, RD:red, Cl: cold, Wa:warm, Da:dark, Li:light,Gr:gray, Co:colored.

Table 2: Independent Sample *t* Tests showing links between the BIG FIVE traits and the six steps.

Significant differences are observed within the groups, indicating that Extraversion has an influence on the 'blue-yellow' choice (introvert: blue; extrovert: yellow). Conscientiousness influences the 'black-white' choice (undependable: black; conscientious: white) and Openness with Extraversion influencing the Hue choice (closed-introvert: cold; open-extrovert: warm). Not significant but still striking differences compared to the other results are Conscientiousness with Neuroticism influencing the 'green-red' choice (undependable-emotional stable: green; conscientious-emotional unstable: red), Agreeableness and the Lightness choice (not agreeable: dark; agreeable: light) and Openness with Neuroticism influencing the Saturation choice (open-emotionally stable: grey; closed-neurotic: coloured).

To check the dependency between the different steps, Pearson Chi-square calculations were performed. Table 3 shows, for the different steps, the significant percentages that a particular colour is chosen in another step. The X^2 and p values demonstrate the significance of these choices.

The 'blue-yellow' and the 'black-white' dimensions show significant correlations with the dimensions of the colour experiences presented as palettes: the 'blue-yellow' choice correlates with the Hue dimension, and 'black-white' with the Lightness as well as the Saturation dimension.

In line with the findings, it would be likely that the 'green-red' dimension correlates with the Saturation dimension. Why it does not can be due to the strong imbalance in the choice distribution with only 28.9% of the respondents who opted for the grey palette, probably caused by its strictly achromatic display. This could also explain the correlation of the 'black-white' dimension with the Saturation dimension.

STEP	PAIR	STEP	PAIR	%	χ^2	*p*
1	**Blue**	4	Cold	63,4	6,72	,01
	Yellow		Warm	56,2		
2	**Black**	5	Dark	61,1	7,47	,01
	White		Light	60,0		
2	**Black**	6	gray	44,4	14,20	,00
	White		Colored	82,0		
n 173, p <,05						

Table 3: Relevant Chi-square Pearson correlations on the steps of the test.

Yet, there is indeed a connection. Gender scores solely and significantly on the 'green-red' (*p* <,05, X^2 12,33) and the Saturation dimension (*p* <,05, X^2 4,16). Women go more for red (71%) and for a coloured palette (77%) than men (resp. 44,7% and 63%). Women's preference for red is confirmed by Hurlbert et al. (2007) and Eysenck (1990) who also explain that women in general are more emotional unstable. It seems likely that both dimensions are associated with the Neuroticism trait.

The interdimensional correlations show connections that tend to confirm a genetic pattern, consisting of three dimensions with polar concepts (2^3), each of which covers a domain of personality compatible with Eysenck's three-factor personality structure. The first dimension with 'blue-yellow' and 'cold-warm' is the Extraversion dimension, the second with 'black-white' and 'dark-light' is the Psychoticism dimension and finally, the 'green-red' and 'gray-coloured' dimension may be connected to Neuroticism. A doubling (2×2^3) creates a refinement of the traits as in Psychoticism that is split into Agreeableness and Conscientiousness. A combination of low Agreeableness and low Conscientiousness reflects Eysenck's Psychoticism personality (Lo et al., 2016).

DIM	STEP	ITEM	EYSENCK	BIG FIVE
1	1	**Blue/Yellow**	EXTRAVERSION	EXTRAVERSION
	4	**Cold/Warm**		EXT + OPENNESS (fantasy, imagination)
2	2	**Black/White**	PSYCHOTICISM	CONSCIENTIOUSNESS (order, discipline)
	5	**Dark/Light**		AGREEABLENESS
3	3	**Green/Red**	NEUROTICISM	NEUROTICISM + CON (planning)
	6	**Gray/Colored**		NEU + OPENNESS (information, ideas)

Table 4: Suggested dimensional pattern in the personality traits and the 6 steps of the colour test.

On the basis of this suggested dimensional pattern, clarification of some observations in Table 2 are necessary. Openness appears on the 'cold-warm' (Extraversion) as well as the 'gray-coloured' (Neuroticism) dimension. When taking a closer look at the specific questions in the NEO-FFI concerning the Openness trait, a clear facet difference is observed. The Openness on the 'cold-warm' dimension is about having fantasy (*p* <,05, X^2 -2,57) and imagination (*p* <,05, X^2 2,47), while the Openness on the 'gray-coloured' dimension is about information (*p* ,06, X^2 -1,87). These findings are confirmed by correlation and factor analysis that show high correlations between

Extraversion and Openness (Aluja et al., 2003; Costa and McCrae, 1992). A strong link between Neuroticism and Openness can be found in the research of Lo et al. (2016). A comparable observation can be made concerning the Conscientiousness trait. On the 'black-white' (Conscientiousness) dimension it is about order (*p* ,06, X^2 1,87) and discipline (*p* <,05, X^2 2,84), while on the 'green-red' (Neuroticism) dimension the facet is planning (*p* <,05, X^2 -2,98). (Table 4)

Additionally, more youngsters choose significantly black (p <,05, X2 -2,90), negatively correlating with Conscientiousness, and the warm palette (p <,05, X2 3,45), correlating with Extraversion. These findings are substantiated by Donnellan & Lucas (2008) who found that Extraversion was negatively associated with age and that average levels of Conscientiousness were highest for participants in middle age.

CONCLUSION

Three out of the six links between the BIG FIVE personality traits and the bipolar colour choices were statistically significant, and the other three were also discriminative in the sense of the magnitude of the differences compared to the remaining equations. Another novel aspect of this study is the observation of a systematic genetic pattern of 2 x 3-dimensional traits, which underpins the evolutionary starting point. Limitations of this study include that the sample size, while valid for correlation testing, may be underpowered. The use of the NEO-FFI with only 20-items may have handicapped the colour test in its comparison with the BIG FIVE personality traits. Also, the display of some colours and palettes may be improved. Other studies using different methods are needed to confirm more convincingly the observed correlations within the genetic pattern. Nevertheless, the present colour test actually does provide information about someone's personality, and in extension about preferences and needs in terms of design. The overall results promise to have great relevance to designers who care about their customers well-being.

ACKNOWLEDGMENTS

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Effects of adjacent chromatic clothing colours on facial skin colour appearance

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ABSTRACT

The purpose of this study is to clarify how colours adjacent to a face such as clothes and cosmetics affect the appearance of facial skin colour. The experiments were carried out in a dark room using an LCD monitor. The stimuli were the images of (1)face and clothes, (2)face and cosmetics, (3)square and square. The skin colour used in the experiment was the average skin colour of Japanese female. The adjacent colours were medium saturated red, yellow, green and blue. The subjects evaluated the skin colour appearance of the test image by 9-point scale for 4 adjective pairs compared with the reference image. As a result, the appearance of the skin colour was changed due to the hue contrast effect when the adjacent colour was outside a face, and on the contrary it was changed by the hue assimilation effect when the adjacent colour was inside a face.

Keywords: *colour appearance, facial skin colour, hue contrast effect, hue assimilation effect, colour induction*

INTRODUCTION

The colour appearance of a female facial skin colour is the most important key factor for colour reproduction. However, it is known that the appearance of skin colour varies depending on adjacent colours such as clothes and cosmetics.

A previous study has reported that background colour made the appearance of skin colour to change and its appearance change tendency could be explained by contrast effect (Imai et al., 2007). The other studies reported that the appearance of skin colour was changed with eye shadow (Kiritani et al., 2017) and with nail colour (Nakajima et al., 2017), and it was explained that these tendencies could be explained by assimilation effect. It has also been reported that the appearance of skin colour was changed depending on the shape of stimulus such as a face or a rectangle (Yoshikawa et al., 2012). Though, it is not clear whether assimilation and contrast effects on adjacent colour to skin colour affects depending on the kind and the area of adjacent colour.

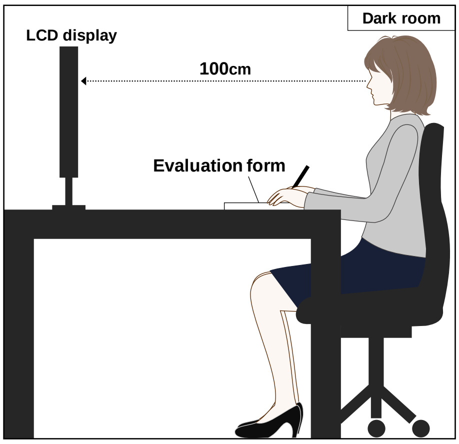
The subjective experiments were carried out in this research to clarify the influence of adjacent colours to skin colour. The experiment stimuli were composed of the combination of (1) the shapes of the skin colour and the adjacent colour, (2) hue of the adjacent colour, and (3) the position of the skin colour parts and the adjacent colour parts.

EXPERIMENT

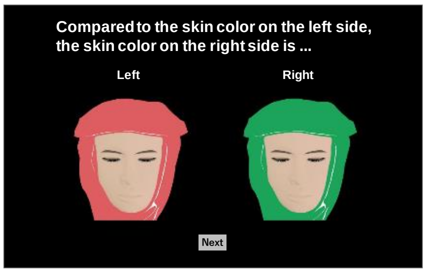
The subjects evaluated the appearance and impression of skin colour of a female facial image with various colours of scarf image and cosmetic image. The image stimuli were displayed on an LCD monitor (EIZO ColourEdge CG 277, the white point 5000 K) which was precisely calibrated to the CIE XYZ system in a dark room (see Fig. 1).

Figure 2 shows the six groups of experimental stimuli, the three face groups are composite images of face and clothes (1: scarf and 2: turtleneck) or cosmetics (3: eyeshadow and lip colours), the other three groups are rectangular images. The three rectangular groups 4, 5, and 6 have the same skin colour area and the adjacent colour area as those of the face groups 1, 2, and 3 respectively.

The colour of the facial image stimuli was set to the average skin colour of Japanese females (the average of *L*a*b** values calculated from the spectral reflectance data of skin colours database: SOCS of 1099 Japanese female cheek skin colour under D_{50} illuminants). The original facial image was a head mannequin photo data shot by Nikon D 7000, then the image was processed using Adobe Photoshop CC 2015 processing. The adjacent colours were the medium saturated red, yellow, green and blue with *L** 59. Table 1 shows *L**, *a**, *b**, *C**, and *h* of the skin colour and the adjacent colours under D_{50}.



(a): The experimental setup



(b): The test image

Figure 1: Observation situation.

The experiment was employed by the Scheffé's paired comparison methods (Nakaya's modified method). The stimulus pairs which were selected from the same category group (ex. Group1) were displayed at the same time on the monitor as shown in the experimental sequence (Figure 4). The subjects with normal colour vision (1 male and 9 females) evaluated the colour appearance and impression of the test skin colour for four adjective pairs ("reddish - yellowish", "bright - dark", "vivid - dull", and "whitish - blackish") by 9-point scale displayed on the right side of the monitor compared with the reference skin colour image on the left side. Each subject evaluated three times on different days.

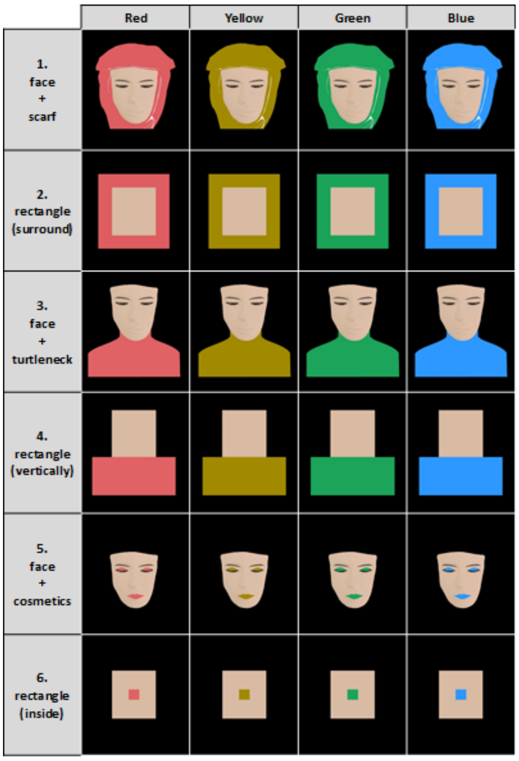


Figure 2: Six groups of the experimental stimuli.

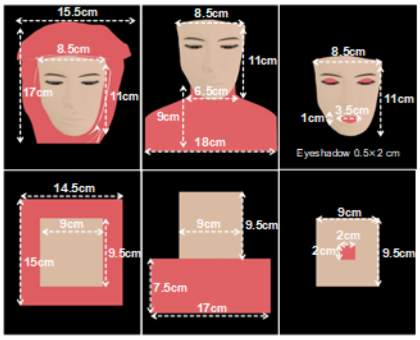


Figure 3: The size of the experimental stimuli.

Table 1: L^*, a^*, b^*, C^*, and h of the skin and the adjacent colours under D_{50}.

	Skin colour	Red	Yellow	Green	Blue
L^*	79.15	59.11	59.02	59.18	59.54
a^*	14.78	59.90	3.74	-60.88	-10.57
b^*	18.02	25.88	64.78	22.80	-64.24
C^*	23.3	65.25	64.89	65.01	65.11
h	51	23	87	159	261

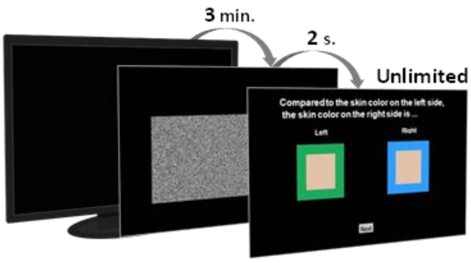


Figure 4: Experimental sequence.

RESULTS AND DISCUSSION

The averages of all subjects data given by the paired comparison experiment were obtained because there were significant main effects for the adjacent colours ($p < 0.05$) except for "6: rectangle (inside)" from the results of ANOVA on each stimulus group.

Figure 5 (a) to (c) show a plot of the average subjective evaluation values for each stimulus on yardstick's Y given by pairs comparison analysis. If the difference between the adjacent colours is larger than the yardstick, it means a significant difference at 5%. As shown in figure 5, the appearance of the skin colour "reddish - yellowish" varied with the adjacent colours, namely these changes were different depending on the type of the stimuli such as the hue of the adjacent colour, the positional relationship between the skin colour and the adjacent colours, and the shapes of the skin colour and the adjacent colour. The results for the skin colour appearance for the stimuli "1: face + scarf", "2: rectangle (surround)", "3: face + turtleneck", and "4: rectangle (vertically)" were similar respectively. Skin colour was evaluated reddish in the adjacent colours of green and yellow, and yellowish in the adjacent colours of blue and red. These results can be explained by the hue contrast effect. On the other hand, for the stimuli "5: face + cosmetics", the subjects evaluated the skin colour reddish when the adjacent colours of red or blue were displayed, and they perceived it yellowish when the adjacent colours of yellow and green was displayed. These results indicate the hue assimilation effect.

Furthermore, when the appearance of skin colour was changed due to the hue assimilation effect or the hue contrast effect, the skin colour impressions such as brightness, vividness, and whiteness were also changed. In the case of the face stimuli, it was evaluated as bright, vivid, and white when the skin colour appearance was evaluated as reddish, whereas it was evaluated as dark, dull, and black when the skin colour appearance was evaluated as yellowish. These tendencies did not occur with the rectangular stimuli at all. In other words, only the face stimuli changed the impression of skin colour when the skin colour altered. Table 2 shows the Pearson's correlation coefficients between the subjective evaluation results of "reddish - yellowish" and those of “brightness”, “vividness” and ”whiteness”. As the correlation coefficients showed high except the rectangle stimuli, the face stimuli were the only significant difference ($p < 0.05$).

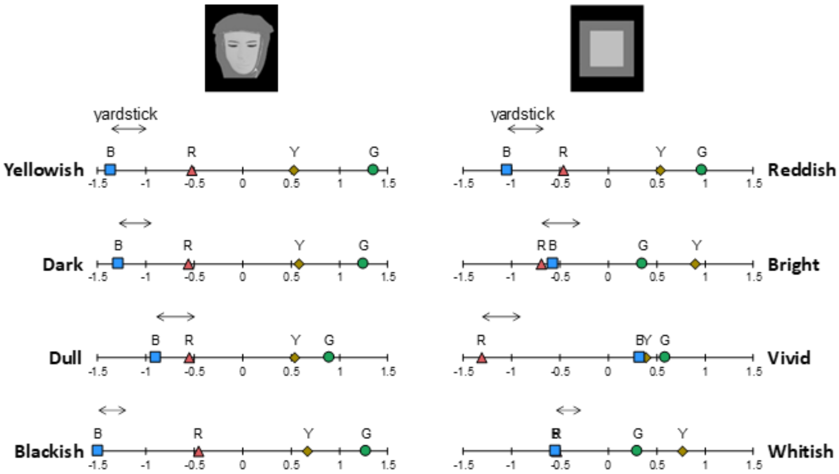
Figure 6 shows the relationship between the skin colour appearance and the hue angle difference, Δh for each type of stimulus. The ordinate of Figure 6 shows the subjective evaluation values of "reddish - yellowish" for skin colour appearance and the abscissa shows is Δh of the hue angle difference between the skin colour and the adjacent colour. As shown in Figure 6, it was clear that the skin colour appearance was changed strongly for the face stimuli than the rectangle stimuli. In addition, as shown in the upper left figure and the left middle figure of Figure 6, it was shown that when the colour difference between the face and the adjacent colour became large which the adjacent colour was green or blue in the case that the adjacent colour was outside the face image, the hue contrast effect appeared strong. On the other hand, as the hue assimilation effect appeared strong when the adjacent colour was inside the face image, the skin colour appearance changed large when the colour difference between the face and the adjacent colour was small, that is, the adjacent colour was red or yellow as shown in the left lower figure in Figure 6.

CONCLUSIONS

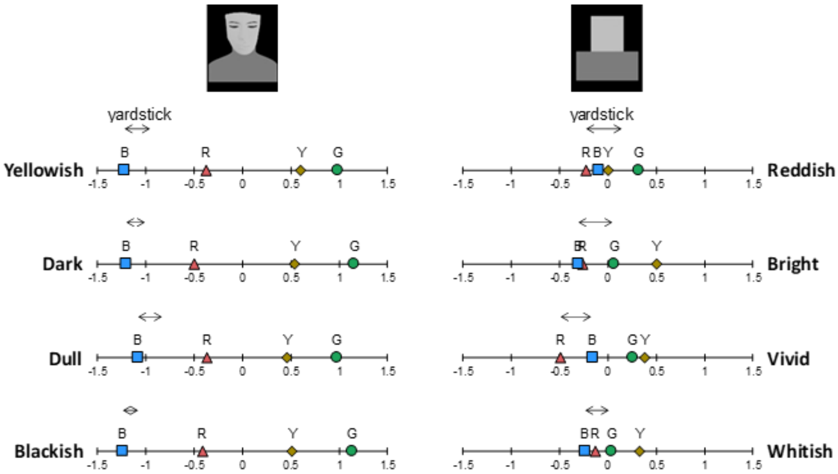
It became clear that the appearance of skin colour differed depending on the colour adjacent to the face image. In particular, the appearance of skin colour varied depending on whether the adjacent colour was on the outside or inside of the face image. If the adjacent colour is outside the face image, it means to wear a scarf or a turtleneck sweater or the like. When the adjacent colour was outside the face image, the hue contrast effect appeared strong. On the contrary, in the case that the adjacent colour was inside the face image, it means that make-up, the assimilation effect appeared strong.

Table 2: Pearson's correlation coefficients between the skin colour appearance and the skin colour impressions. *: significant difference ($p < 0.05$)

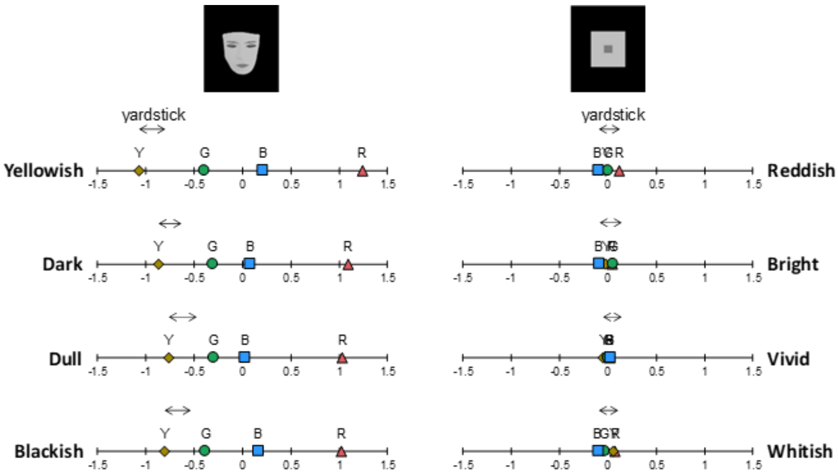
	1. face+scarf	4. rectangle (surround)	2. face+turtleneck	5. rectangle (vertically)	3. face+cosmetics	6. rectangle (inside)
	Reddish – Yellowish					
Brightness	**0.998***	0.832	**0.994***	0.414	**0.997***	0.817
Vividness	**0.984***	0.434	**0.997***	0.744	**0.992***	0.084
Whiteness	**0.995***	0.855	**0.996***	0.384	**0.998***	0.802



(a): Results of the stimulus group “1” and “4”.



(b): Results of the stimulus group “2” and “5”.



(c): Results of the stimulus group “3” and “6”.

Figure 5: Plots of the subjective evaluation values (means) for each stimulus on yardstick’s Y.

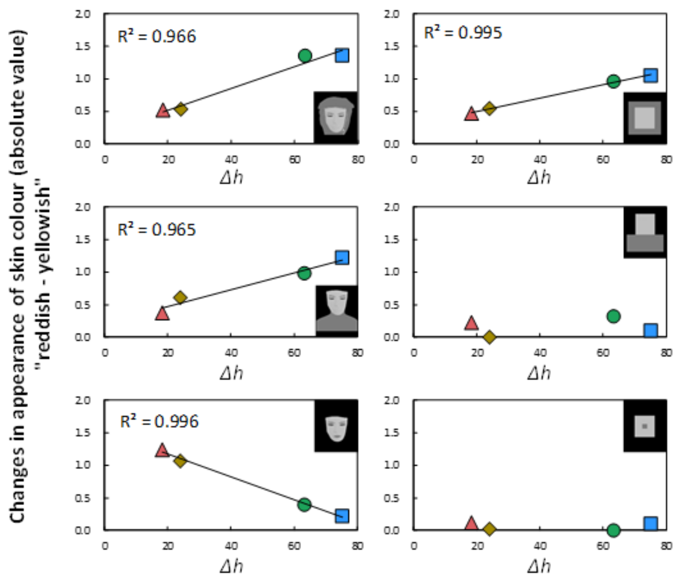


Figure 6: Relationship between the skin colour appearance and *Δh* for each type of stimulus. *Δh*: the difference between the skin colour and the adjacent colour

The result that the appearance of skin colour changes strongly with respect to the face stimulus rather than the rectangular stimulus indicates that the shape of the face has a large influence. It was also suggested that the skin colour appearance might be influenced depending on whether the adjacent colours was part of human body or not.

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Architects and Chromophobia: black and white as a moral choice

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ABSTRACT
Contraposition between colour and non-colour, or between black/white and colours, is so ingrained in modern mentality that it is difficult to trace the origins of such a phenomenon. Almost always a-acromia was associated with a value of sobriety, seriousness and respect, and the colour values reappointed to lightness, frivolity or a rather unspecific sense. The world of art, as well as culture in general, is full of examples in which colours are considered baroque and excessive, having as a counterpoint the chromatism as a symbol of rectitude. More than a formal choice, the choice for no colour in art, design, taste, is often a true ethical principle. During capitalism, the choice for dressing dark becomes a symbol of social status and success, especially among those who succeeded in life and won their own fortune, not by family privileges, but by workplace skills. In our approach, we cannot fail to consider the producers of architecture, which increasingly choose the chromatic anonymity which translates in black for the costumes and white for the buildings.

Keywords: *Black, White, Architects, Morality, chromophobia*

INTRODUCTION

As some authors such as Riello (2013) argue, black in the clothing arises in contrast to the excesses of ostentation and pure posture of the material values that were attributed to the men of the sixteenth century. Black represents the renunciation of the mundane/worldly, emphasizes the aesthetic, cultural and intellectual values of those who renounce the mundanity, choosing the sobriety, the dignity of a life that goes beyond ostentation.

One of the most interesting documents that faces this paradigm change is the famous portrait of Baldassare Castiglione (1478 - 1529) made in 1514-16 by Raffaello Sanzio (1483-1520), painter and architect. Castiglione, one of the most influential authors of the Renaissance, is recognized as a man of dignity: with his black velvet jacket, unbleached white shirt and a black beret hat. It is a portrait that shows the ethics that a courtier, a virtuous man must have, avoiding excesses in order to be recognized and appreciated by society, renouncing the *vanitas* of a mundane/worldly and futile life.

Black is the predominant colour in the royal portraits of the Spanish royal house like those portraying Filippo II and Filippo III, as it will be in the genre painting of Netherlands where the values of the mercantile bourgeois society are highlighted through the portraits of solemn and hierarchical groups.

Black will also be the typical male costume in a predominant form from the middle of the nineteenth century, acting in opposition to the excesses of pre-revolutionary clothes and also to the clothes of women who were part of the family unit: wives, daughters and lovers, a real showcase of the social status of the bourgeoisie.

The black, and the sobriety of the dark colours of men's clothing, will help to underline its adaptation to the austere universe of the world of commerce and business and of the profession in the social contests of the nineteenth and twentieth centuries.

The element that makes this attitude more curious is that dressing black is a choice which overcomes gender differences: men and women in architecture choose black sobriety. When in fact we know historically that women were reserved the colourful and pompous dresses but social roles of facade and reflection of the social condition of the family, contrasting the male bourgeois universe, where the formal sobriety was inversely proportional to the amount of social and economic power.

SOCIETY: COLOUR MEANS MORALITY

The dualism between colour and non-colour was typical of the choices made by society for centuries. It is an ancient theme, of which we still unconsciously live the consequences. This contrast takes on moral connotations that lead to a real chronophobia when we relate to the themes of art and architecture. The art cinema often identified itself with black and white, refusing colours considered as a manifestation of a frivolous thought. Even photography often chooses the absence of colour in order not to be excessively influenced by the realism of events.

If we shift our attention to the field of society, non-colour is synonymous with composure and behavioural aridity. It is a true ethical imperative in many cases; dressing in black indicates a symbolic form of moral measure, inner virtue. Using black clothes in the era of capitalism was also a sign of a certain economic prosperity, because dyeing the fabrics in black required an expensive technique.

Loos himself makes this social distinction when he associates the choice of a coloured shirt with a popular class, considering it a serious mistake not of taste but of behaviour: *"But here too mistakes are made. (...) recently in the giuseppina city [Vienna. Author's note] I even saw the dinner suit with a coloured shirt. Perhaps you will object to me that he was a shoemaker. Well, you would be amazed if you heard the man's name".* (Loos, 1903: 10)

Even dressing in black in mourning was an ostentation of this economic possibility, while the less affluent classes went to funerals as they could, dressing their best outfit.

The problem of clothing suitable for every occasion in Adolf Loos's speech becomes a question of modernity and behavioural training, I must be able to recognize, making "limitations" within the environment I find myself and I must know how to respond to the behavioural needs that this particular environment requires of me. And then: "How do you have to dress?" it is asked in the pages of Das Andere: "In a modern way. When are you dressed in a modern way? When you don't stick out. I do not stick out. Then I leave for Timbuctu or Krätzen-kirchen. Here they stare at me with amazement. So, I have to limit myself.

You are dressed in a modern way when you are not in the spotlight at the central point of Western civilization. I wear brown shoes and a sack dress. And I go to a dance party. And again I draw attention. So, I have to do a limitation again. You are dressed in a modern way when in the central point of Western civilization and on a particular occasion you don't attract people's attention. It's afternoon and I'm delighted not to catch on with my gray pinstripe trousers, my financier and my top hat. Because I'm walking to Hyde Parke. I'm strolling and suddenly I'm in Whitechapel. And again, I am noticeably in the spotlight. So I have to do a limitation again. You are dressed in a modern way only when in the central point of civilization on a given occasion and in the BEST society you are not noticed." (Loos, 1903: 8)

ARCHITECTS: THE DRESS I LIVE

> *"The dress is the zero degree of architecture, a kind of portable building, a homologous building. We find an evident continuity in the progression that goes from the shirt to the tunic, from the cloak to the blanket, from the sleeping bag to the tent to end at the hut.* "(Espuelas, 2012: 121)

We inhabit our bodies as we experience our house, as we inhabit our clothes. The object amplifies our biological possibilities, becoming an object-prosthesis, but it can also represent an object-sign, signifier of possible meanings. The object becomes language and at the same time a witness of identity. Language very often refuses to consider both architecture and clothing on the same level of objects, although *"both architecture and dress aspire to surround the body. Both refer to the body in its unity, unlike the other objects that concern only a part of it, a hand, the eyes, the skin*." (Espuelas, 2012: 125)

Architecture and dress differ because of the different distance they establish with respect to the body: the dress reduces it, as if to transform itself into the same body; architecture looks at it from a distance, giving it shelter but not preventing it from being identified. At the exact moment I enter my dress, I borrow a new skin, which will protect me and identify me, and that will be my "home" when I won't have anything but the emptiness around me.

Clothes prolong us, introduce us to society, represent us for what we have the illusion of being. Even when we store them, folded at the bottom of a drawer or organized in a closet, this self-presentation monologue of us never stop. At the very moment in which we "live" them, they establish a bond, they take our form, and inhabiting them will keep it for a long time. They will be our smell, our specific forms, our physical defects, our imprint, the presence of our memories.

Of great interest are, for example, the fascinations that in the '60s the Archigrams had for the territory that is no longer “dress” but not yet architecture. Michael Webb proposes Cuchicle (1966) or Suitallon (1968), which are nothing more than attempts to insert themselves into the ideation process halfway between the creation of the artefact and of the dress. Stelarc asserts: *"The body is not the object of desire but the object of a project"* (Sterlac, 1991: 591-594).

There is a social category that turns these two words into a daily use: architects. They build a house with the same diligence with which they choose a dress. They bleach architecture with the same skill with which they darken their clothes. So, it is not unusual to find architects dressed in black to whom they can be associated architectures dressed in white.

In official events and congresses, where the target is to show that you know, even the way we dress this knowledge tells something about ourselves. Then our knowledge becomes a *status symbol*, and our social status in the architectural discipline must be understood as serious and anonymous. The creativity is left only to small but eloquent details (glasses, bags, various jewels) to which we entrust the necessary human need to differentiate ourselves. Goethe used to say that people of a certain cultural refinement are not interested in chromatic issues and they are disinterested in bright colours, as if good taste were automatically associated with measured colours.

This assuming a "cultured livery" represents a will of anonymity that has nothing anonymous. It is an absence that has the objective not to leave room for anything else but rather to be inserted and to be recognized in a category officially and socially considered "educated", "high", "important", "powerful".

The monochromatic should serve to communicate that what is important is not me with my body, but what my mind is able to create. Actually, what communicates in this case is: "I am my renunciation of colour", and my renunciation connects me to a sequence of historical social and moral precedents that support and establish it.

Asked why architects wear black, their answers gave rise to a publication where a series of handwritten answers appear with a small English translation to the side. Many border on banality, voluntary or as a provocative gesture. Some open up some interesting questions. "*To disappear into space*. Hani Rashid, New York ", the will to give absolute protagonism to the space, forgetting that the space is not black. Some make it a matter of fashion: *"Elegance. Neutrality. Hiding. Status symbol. Not a fad.* Wolf D. Auch, Munich;" others of social action: *"Architects are missionaries.* Hermann Kaufmann, Schwarzach ". Some respond in relation to colours: *"Black is the colour of creatives: mysterious, deep, defined. Goes with every colour.* Eike Becker, Berlin "; *"Why do architects wear black? Because they want to appear neutral face-to-face with space and colour. Because they could be afraid of colours ... I don't really wear black. The colour of holiness.* Lucas Young, Berlin ". In many answers, white is the opposite of black: *"Because black is the mirror of white (a serious architectural problem* (...) Chris Dercon, Munich"; *"I wear black because around the lunatics, everything is white."* Odile Decq , Paris ". (Rau, 2017)

Actually, in terms of austerity, black is considered a contrast to the coloured, while white is associated with values such as purity and incorruptibility. (Falcinelli, 2017: 303)

White is associated with classicism, wrongly considering that ancient statuary and classical architecture has renounced colour from the very beginning of its conception. The choice of monochromatism was considered a form of protest against the new form of seduction represented by technology, giving way to frivolity and luxury: *"the more commercial images become coloured and pervasive, the more the elite contrasts the candid rarefaction of an ideal classicism that never really existed".* (Falcinelli, 2017: 305) This attitude denotes fear not so much for the colour itself, but for what the choice of colour can represent on the social level.

The history of architecture, especially that of the twentieth century, has helped to reinforce this choice with illustrious contributions. Le Corbusier considers white as a defence against the deafening noise of everyday life. (Le Corbusier, 1923)

> *Distinctive of authenticity, international and novelty index for Le Corbusier: "when the cathedrals were white, Europe had organized the jobs according to the imperative request of a completely new, prodigious, insanely daring technique, whose employment led to some systems of unexpected evolutions: therefore, to forms in*

which the spirit disdained the legacy of a thousand years of tradition, not hesitating to project civilization towards an unknown adventure. An international language reigned wherever the white race resided, thus favoring the exchange of ideas and the passage of culture. An international style had spread from the West to East and from North to South - a style that brought with it the torrent of passionate spiritual pleasures: love for art, disinterestedness, joy of living creating. The cathedrals were white because they were new. The cities were new: of any measures, ordered, regular, geometric, according to specific projects. The freshly cut stone of France was shining with whiteness, just as the pyramids of Egypt had been polished with polished granite. (...) A new world began. White, clear, joyful, clean, clean and without returns. Everything that had been recognized as tradition were abandoned: they turned their backs on it. One hundred years of prodigy took place and Europe was changed. The cathedrals were white." (Le Corbusier, 1937: 7-8)

In architecture the rational is white, as well as in the South the whiteness of the lime is associated with the walls or the plaster or the monochromatic material seduction of the stone. The colour seems to distract from the real protagonist that is the architecture.

As concerns Luigi Cosenza, just to cite an example, thanks to his link to the humanism of his land, the Mediterranean takes on a completely different meaning from the one assumed by MIAR, or the nationalistic retreating of some elements of the Group 7. His design evolution, starting from the rationalism of the Fish Market (1929-1930), passing through the monumentalism of the Palazzo Littorio project (1934), up to the purism of Villa Oro (1934-1937), shows that the Mediterranean, for him, does not assume historical and symbolic qualities (intended as national quality or expression of the Roman tradition), but a functional and economic superiority. (Moccia, 1994: 54) For many others, white is associated with an idea of adequate functionality, rather than assuming a true chromatic symbolism.

FINAL REFLECTION

As Steele (2017: 85) says about the triumph of black since the mid-19th century in men´s clothes: "black was ´less` in as much as it signified the absence of colour, but it was also ´more´ because its symbolism was so rich and multifaceted". The history of black in men´s clothing is also the history of a range of elegance, authority, respectability, strength and power: why do architect´s wear black? Maybe on the account of this.

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colour & human comfort

In depth-analysis of the Number of Salient colours in Natural images.

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ABSTRACT

Colour diversity of natural images and its dependence with natural spectra, local colour properties or the probabilistic nature of observer judgements have been extensively studied. During the past decade many works have been also developed trying to find algorithms to evaluate where humans look, i.e. the saliency map, in a scene based on a reduced number of visual features. In the present study we have analysed the influence of salient regions in the number of discernible colours. When the percentage of reduction of the average number of discernible colours between the salient regions and the original images was computed, a reduction in the number of them between 40% and 63% was obtained, being always 7%–18% above the number computed in the regions of the image with the same number of pixels obtained masking the original image with the horizontally and vertically flipped and 180° rotated salient masks.

Keywords: *Natural images, Number of discernible colours, Saliency.*

INTRODUCTION

The number of discernible colours as a descriptor of chromatic diversity was estimated by Pointer and Attridge [1] at about million under illuminant D65 in the CIELAB colour space and idealized object–colour solid. Nevertheless, this number is smaller when natural images are considered. Linhares et al. [2] estimation is about $2.7x10^5$ suggesting that this reduction is due to the natural spectral reflectances that are different from the idealized ones.

But colour diversity could depend on other visual cues. Amano et al. [3] found that a high percentage of the variance in observers' detection performance over scenes could be explained by local colour properties. When the observer response uncertainty is taken into account using information-theoretic methods [4] more than an order of magnitude lower than the number reported by Linhares et al. [2].

Several works [5-7] have been also developed trying to find algorithms to evaluate where humans look, i.e. the saliency map, in a scene based on a reduced number of visual features as luminance, orientation, or colour. Nevertheless, the influence of salient areas of the images attracting observers' attention in the study of colour diversity has deserved little attention. In [8] we found that chromatic diversity was strongly reduced when a hypothetical observer scans a natural scene; a significant reduction in the number of discernible colours was found but only natural images were considered in that study.

METHOD

In this work we have used a set of 600 RGB 400x400 pixels images classified in two broad categories: Natural images and man-made environments. The first natural image set was divided in seven semantic groups: Forests, Fields, Shores, Flowers and fruits, Mountains, Beaches, and Rivers; and the man-made environment images were classified depending on their contents into: Highways, Cities, Buildings, Indoors and Streets. Each subcategory was composed of a set of 50 pictures collected by the authors and selected from the SUN Database [9]

Images simulation under different SPD of daylight

Every RGB image was normalized to the range [0, 1] and simulated under different SPD of daylight characterized by their respective CCTs within the visible range [400-700] nm. The simulation was made using Judd colour matching functions [10] and the Bradford chromatic adaptation matrix. [11]

The real daylight SPDs were measured in Granada, Spain, from sunrise to sunset under different atmospheric conditions and covering a vast range of CCTs from 4,800K up to 30,000K [12]. The simulated daylight SPDs were obtained with SBDART, a software tool to compute plane-parallel radiative transfer energy in clear and cloudy conditions within the Earth's atmosphere and at the surface [13] to cover CCTs below 4,800 K.

Finally, the simulated pictures were transformed to the CIELAB colour space and the L*, a*, and b* colour components were computed for all images.[14]

Saliency maps

The visual saliency maps are topographical codifications of fixation position in visual search over the entire scene based on different image features such as luminance, orientation, or colour [6]. In the colour saliency model used here [7] every picture was transformed to the Hue-Saturation-Intensity (HIS) colour space. Five saliency maps were obtained for each image corresponding to features: contrast of hue, contrast of saturation, contrast of intensity, dominance of warm colour, and dominance of brightness and saturation. The saliency map was a weighted linear combination of the five conspicuity maps normalized.

Figure 1 shows the process followed to mask the original images with their saliency maps. The original CIELAB images are first converted to HSI images and the integrated saliency map is calculated. Next the salient objects are extracted from their background segmenting the integrated saliency map, and a thresholding method [15] with threshold the average of the integrated saliency map is used. A region of interest (ROI) map is applied to the segmented saliency map to remove noise [16], and finally HSI images are masked with ROI maps and converted back to CIELAB image format.

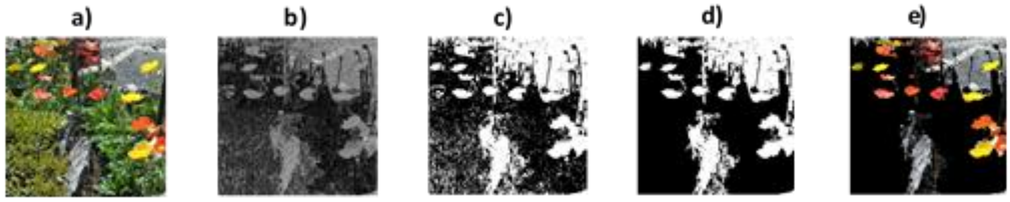

Figure 1: Masking original images with their integrated saliency maps process: (a) original image, (b) integrated saliency map, (c) integrated saliency map segmented, (d) ROI map, and (e) masked image with ROI map.

Number of discernible colours.

The general principle behind the estimation of the number of discernible colours is to segment the colour space in just noticeable sub-volumes and to count the number of these volumes containing the colour representation of at least one pixel. We used in this work the square-packing method that assumes a unit cube to be one discernible colour in a Euclidean colour space. The L*, a*, and b* values of each pixel were rounded to the nearest integer greater than or equal to the pixel value. In that way all the values falling inside the same cube are grouped in the upper corner of it.

RESULTS AND DISCUSSION

The number of discernible colours and the times of occurrence of each colour were calculated for the original and the salient images. The chromatic distribution was characterized computing the fraction of discernible colours expressed as a function of the number of times of occurrence in every image [17]. Both magnitudes are related by a power law in a log-log scale where slope could be obtained. Figure 2 shows the averaged slope distribution for natural and man-made environment images considering both the original images and only their salient regions.

Our results show lower (in absolute value) slopes for salient regions of the images (-0.93 for natural images and -0.95 for man-made images, on average) than for the original ones (-1.37 and -1.22 for the both categories respectively). These values indicate that salient regions have less colours than their corresponding original images keeping most of the greatest uniform chromatic areas of the original ones. In both categories results are near the same.

Table 1 shows the average number of discernible colours for original and their salient regions of the two sets of man-made and natural environment pictures simulated under 108 daylight CCTs. Results are similar for both categories although the range for natural images (7945 for Beaches – 31625 for Flowers and Fruits) is wider than for man-made images (13234 for Highways and Roads – 20108 Indoors).

Obviously, the number of discernible colours in the salient regions should be below the corresponding number when the whole image is considered (as the salient region will contain less number of pixels). Our results suggest a reduction of number of discernible colours between 44% and 63% when the salient regions of the original images are considered instead of them. To check the proportion of this reduction corresponding to a salient region, every computed ROI map was flipped horizontally and vertically and rotated 180°. In Figure 3 we can see an example of the transformations given to the calculated ROI map. The images were subsequently masked again with the transformed maps and the number of discernible colours were computed for those new areas.

	Average number of discernible colours for original images	Average number of discernible colours for salient regions	Average Percentage of reduction (%)
Forests and Parks	23271	10152	56
Fields	14641	5374	63
Coasts	10644	4675	44
Flowers and Fruits	31652	12525	60
Mountains	9789	3822	61
Beaches	7945	4432	44
Rivers and Falls	12926	5845	55
Natural Images	15838	6689	58
Highways and Roads	13234	6140	54
Cities	16531	6486	61
Buildings	15096	6088	60
Indoors	20108	9086	55
Streets	18524	7755	58
Man-made images	16699	7111	58

Table 1: Average number of discernible colours for the original and their salient regions of the two sets of man-made and natural environment pictures simulated under 108 daylight CCTs.

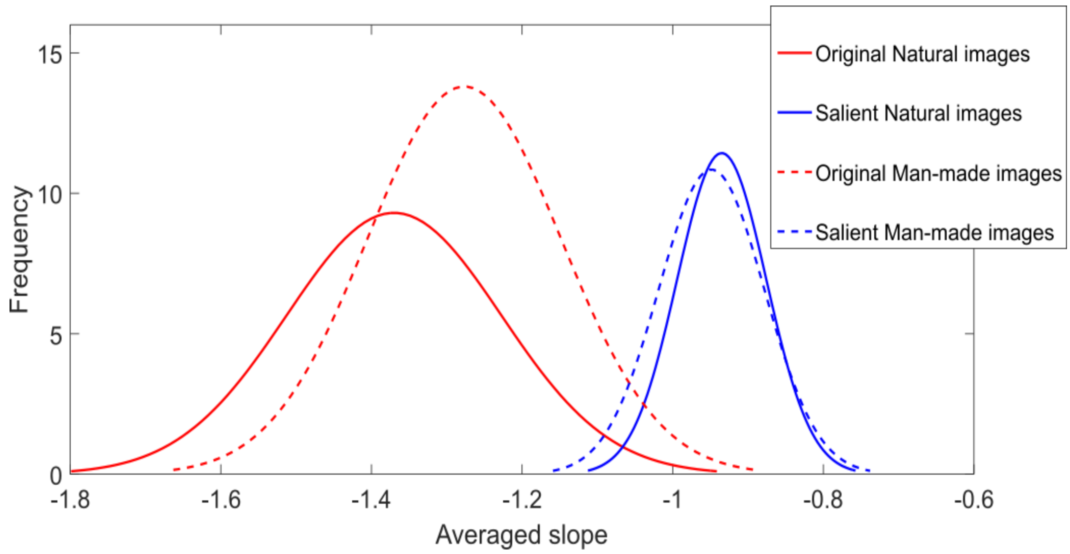

Figure 2: Averaged slope distributions of the power law of the fraction of discernible colours as a function of the number of occurrences for Original and their salient regions of natural and man-made environment images.

The results show that the reduction in the number of discernible colours for the salient regions is always 7%–18% above the number obtained when salient regions are not considered in the computation, i.e., using the rotated and flipped mask, even considering that the number of pixels in both computations was kept constant. This diminution in the chromatic diversity when images regions attracting observers' attention are considered is general for both sets of images natural and man-made environments and all semantic categories except beaches and coasts (with big uniform areas), where the number is almost constant.

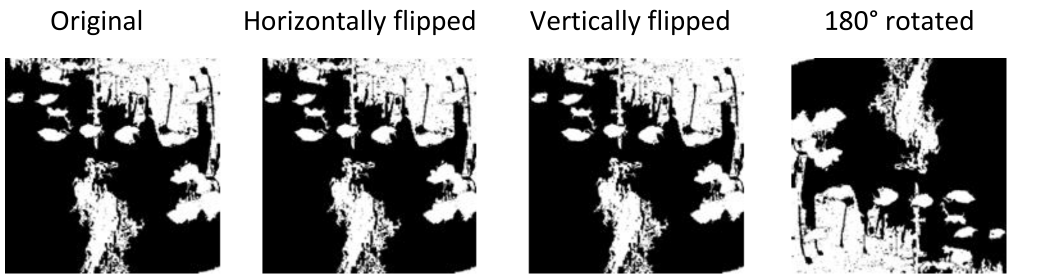

Figure 3. Example of the transformations of the calculated ROI map applied as new salient masks to check the proportion of reduction of number of discernible colours due to fixation positions.

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Image of Purple and Orange by Pleasantness Seekers and Comfortableness Seekers (2): Difference between Males and Females

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ABSTRACT

Relationship between individual's colour preference and his/her personality concerning pleasantness and comfortableness, active and passive kinds of our good feeling, was examined. Two hundred and eighty-six university students answered the questionnaire that asked his/her degree of preference of twelve colours, tendency of seeking pleasantness and comfortableness, and the image of purple and orange colours. After analysing males' and females' data separately, it was found that males feel purple more restful than females, and females feel orange more restful than males. Moreover, females with stronger pleasantness-seeking tend to feel purple restful, but males with stronger pleasantness-seeking do not. As regards colour preference results, relationship between pleasantness seeking and purple preference, nor between comfortableness seeking and orange preference, which has been shown in our previous studies, was not found. Some sex differences found in this study concerning image of colours and its relationship with pleasantness/comfortableness seeking should be further investigated in the future with accumulation of data and theoretical elaboration.

***Keywords: Colour** preference, Colour image, Pleasantness and comfortableness*

INTRODUCTION

Following our previous research that has been presented in the last three AIC meetings (Takahashi and Hanari, 2015; Takahashi, Hanari, and Miyake, 2016, 2017), relationship between individual's colour preference and his/her personality concerning pleasantness and comfortableness was examined. Pleasantness is an active kind of our good feeling that is characterized by properties such as excitement, change, and surprise. Comfortableness is a passive kind of our good feeling that is characterized by properties such as calmness, stability, and ordinariness.

In the last year (Takahashi, et al., 2017), we focused our interest on the relationship between pleasantness seeking and purple preference, and between comfortableness seeking and orange preference, since these relationships have been found in the preceding two studies (Takahashi and Hanari, 2015; Takahashi, et al., 2016). The results showed that pleasantness seeking had a positive correlation with restful image of purple, and comfortableness seeking had a positive correlation with restful image of orange, suggesting mental affinity between pleasantness and purple colour, and between comfortableness and orange colour. However, unlike the preceding studies, correlation between pleasantness seeking and purple preference, nor between comfortableness seeking and orange preference was not found. Unbalanced sex ratio of participants in that study (50 males vs. 128 females) was supposed to be one of possible causes of such unexpected result. Consequently, in the present study, we re-examined the same question by increasing data samples, especially those of males, in order to investigate possible difference based on participant's sex.

EXPERIMENTAL

Participants

Together with old samples (Takahashi, et al., 2017), a data from two hundred and eighty-six participants (136 males and 149 females, 1 unspecified) was analysed. Their mean age was 20.0 years old (SD=1.64).

Procedure

We employed the same questionnaire as in Takahashi, et al. (2017) that was composed of three parts.

The first part included twelve visual analogue scales on which participant answered his/her degree of liking of twelve colours; red (5R 4.5/14), orange (10R 6/11), yellow (5Y 8.5/12), yellow-green (5YG 6.5/9), green (5G 4.5/10), blue (2.5PB 4/11), purple (10P 4/11),

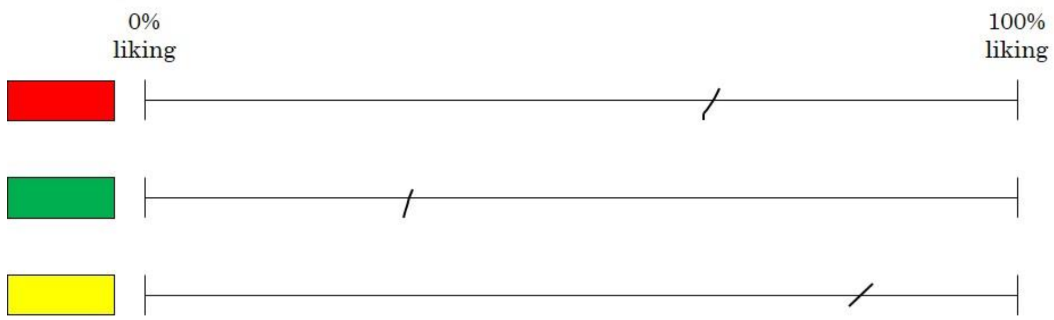

Figure 1: Samples of the visual analogue scales.

pink (5RP 6.5/9), brown (7.5R 4/6), white (N9.5), grey (N5.5), and black (N1.5). These colours were presented as printed colour chips (6 mm × 16 mm). Participants drew a slash, according to the degree of liking of each colour, on the line with the left-end indicating 'do not like at all (0% liking)' and the right-end indicating 'like the most (100% liking)' (Figure 1).

The second part included ten short statements, and asked participants to answer the degree of his/her agreement to each statement on 11-point scale (0: 'do not agree at all' – 10: 'completely agree'). Five of ten statements were intended for measuring pleasantness seeking; 'always seek the impression never experienced,' 'want to try new things,' 'prefer eventful life to steady life,' 'unexpected things are intriguing,' and 'want to take a chance even if somewhat risky.' Other five were intended for measuring comfortableness seeking; 'want to lead ordinary and steady life,' 'do not want to change the present situation, if satisfactory,' 'usualness makes me feel most peaceful,' 'do not want more than no-dissatisfaction,' and 'prefer comfort of ordinariness to the impression of new things.'

The third part was the semantic differential (SD) scales to measure the mental image of purple and orange colours. Eight adjective pairs, on eleven-point bipolar scales, were employed; 'positive – negative,' 'surprising – unsurprising,' 'artificial – natural,' 'ordinary – unordinary,' 'stable – unstable,' 'relieved – uneasy,' 'restful – tensed,' and 'having unexpectedness – not having unexpectedness.' Purple and orange colours to be evaluated were the same as in the first part, and the order of their presentation was counter-balanced among participants.

Data analysis

As for the results of the visual analogue scales (part I), position of the slash was visually measured and converted into the preference score ranging from 0 (the left-end) to 100 (the right-end) for each colour.

Ratings of agreement to statements (part II) underwent factor analysis (maximum likelihood method, Promax rotation), and two factors were obtained, one loaded highly to five pleasantness statements and the other loaded highly to five comfortableness statements. Thus, mean of ratings of five pleasantness statements and mean of ratings of five comfortableness statements were calculated in each participant to indicate the degree of his/her pleasantness seeking (P score, α=.871) and the degree of his/her comfortableness seeking (C score, α=.845).

The results of the SD scales (part III) underwent the same factor analysis as above, and two factors were obtained. The first factor loaded highly to 'relieved,' 'stable,' 'restful,' 'positive,' and 'natural,' and was named *Restfulness*. The second factor loaded highly to 'surprising,' 'having unexpectedness,' and 'unordinary,' and was named *Surprise*. The means of ratings for these items were calculated to indicate factor scores in each participant (α=.767, .488, respectively).

RESULTS AND DISCUSSION

Preference scores of twelve colours

Mean preference scores of each colour, in all, male and female participants, are shown in Table 1, which are ordered by the grand mean. Top four colours, white, blue, black, and red, have not been replaced with other colours, though their order changed sometimes, in fifteen years during which we have collected data. These colours (white in particular) have been stably liked by Japanese young people. In addition, significant sex differences were found in blue, yellow-green, and green, which were liked more by males, and in pink and white, which were liked more by females.

Table 1: Mean preference scores in all, male, and female participants. *p<.05, **p<.01, ***p<.001

	white	blue	black	red	orange	y-g	yellow	green	pink	gray	purple	brown
All	76.3	71.5	70.0	66.1	61.1	59.6	57.8	57.6	57.2	57.0	52.1	45.1
Male	72.8	75.9	69.7	64.2	63.4	62.5	56.7	60.9	46.7	57.1	49.1	45.3
	*	**				*		*	***			
Female	79.3	67.7	70.6	67.6	58.8	56.7	59.0	54.3	66.5	57.2	54.4	45.2

Colour preference and seeking pleasantness and comfortableness

Correlation coefficients between P and C scores and the preference score of each colour are shown in Table 2a and 2b, separately for male and female participants. Correlation between pleasantness seeking and purple preference, nor between comfortableness seeking and orange preference was not found in either dataset. To say more generally, relationship between preference of any colours and P and C scores found here is weaker than our previous data (Takahashi and Hanari, 2015; Takahashi, et al., 2016).

To compare Table 2a and 2b, some sex differences are found. Pleasantness-seeking females, but males do not, tend to like warm colours such as red and orange. Comfortableness-seeking males, but females do not, tend to dislike brown. However, these correlations are not strong anyway.

Table 2a: Correlations between P and C scores and colour preference scores in male participants. *p<.05

	white	blue	black	red	orange	y-g	yellow	green	pink	gray	purple	brown
P score	.116	.129	.125	.060	.130	.110	-.094	.096	.012	.038	.128	.077
C score	-.127	.149	.101	.038	-.036	-.068	.151	.013	-.099	-.072	-.101	-.199*

Table 2b: Correlations between P and C scores and colour preference scores in female participants. *p<.05, **p<.01

	white	blue	black	red	orange	y-g	yellow	green	pink	gray	purple	brown
P score	.041	-.035	-.004	.222**	.188*	.130	.128	.122	.052	-.074	.008	-.029
C score	.077	.021	.005	-.131	.029	-.093	.096	-.044	-.002	.075	-.079	.030

Image of purple and orange and seeking pleasantness and comfortableness

Correlation coefficients between P and C scores and factor scores of purple image and orange image are shown in Table 3a and 3b, separately for male and female participants.

First, P score and C score correlated negatively in both sexes, suggesting that pleasantness and comfortableness are exclusive to some extent; a pleasantness-seeking person tends not to seek comfortableness, and vice versa. Similarly, *Restfulness* of purple and *Restfulness* of orange correlated negatively in both sexes, showing that one who feels purple restful tends not to feel orange restful, and vice versa. In this respect, purple and orange colours would have contrasting characteristics that are sensed differently by each individual.

Finally, another sex difference was shown in orange image. *Restfulness* and *Surprise* of orange correlated negatively in females, but not in males. In females, restful image and surprising image may be incompatible in orange. Interestingly, however, these images may not be incompatible in purple.

Table 3a: Correlations between P and C scores and factor scores of purple and orange in male participants. *p<.05, ***p<.001

	P score	C score	p-*Restfulness*	p-*Surprise*	o-*Restfulness*	o-*Surprise*
P score	—	-.489***	.161	.090	-.005	-.069
C score		—	.003	-.080	-.042	.088
purple-*Restfulness*			—	-.124	-.394***	.005
purple-*Surprise*				—	.170*	-.014
orange-*Restfulness*					—	-.099

Table 3b: Correlations between P and C scores and factor scores of purple and orange in female participants. **p*<.05, ***p*<.01, ****p*<.001

	P score	C score	p-*Restfulness*	p-*Surprise*	o-*Restfulness*	o-*Surprise*
P score	—	-.465***	.184*	-.072	-.128	.146
C score		—	-.064	.076	.083	.101
purple-*Restfulness*			—	.065	-.273**	.023
purple-*Surprise*				—	.075	-.033
orange-*Restfulness*					—	-.182*

Sex difference in P score, C score, and factor scores of purple image and orange image

Table 4 shows mean P score, C score, and factor scores of purple image and orange image in male and female participants. It was found that males feel purple more restful than females, and females feel orange more restful than males.

To consider this result together with that in Table 3b, females in general, as compared to males, may not feel purple colour restful. Among them, some 'special' females who tend to seek pleasantness would be likely to find restful image in purple. Males, on the other hand, may feel purple colour restful to some extent, regardless of degree of seeking pleasantness.

It is interesting that there was sex difference between feeling restfulness in orange, as well as in purple, whereas there was no sex difference between degrees of liking these colours (Table 1). These results suggest that males and females are likely to see different aspects of the multiple images of purple and orange, and probably of many other colours.

Table 4: Mean scores in male and female participants (range: 0 – 10). ***p*<.01, ****p*<.001

	P score	C score	p-*Restfulness*	p-*Surprise*	o-*Restfulness*	o-*Surprise*
Male	5.54	6.42	4.25	5.35	6.01	5.14
Female	5.26	6.85	** 3.73	5.02	*** 6.71	5.41

CONCLUSION

Unlike the preceding studies (Takahashi and Hanari, 2015; Takahashi, et al., 2016), clear relationship between pleasantness seeking and purple preference and its image, nor between comfortableness seeking and orange preference and its image was not revealed. However, some sex differences were found in feeling restfulness in these colours and its relationship with pleasantness seeking as personal characteristics. Further accumulation of data and elaboration of theoretical basis are necessary to clarify these problems.

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Investigating Perceptual Appearance Qualities of Real-World Materials under Different Illuminations

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ABSTRACT

Humans instantly recognize material appearance using the object surface and environment information, while also judging its perceptual appearance qualities. In recent years, many studies have investigated perceptual material appearance using mainly computer graphics (CG) stimuli. However, the study of perceptual appearance using real-world materials has not been made abundantly clear even though the appearance of CG and real material stimuli are not quite similar. In this study, we investigate the perceptual appearance qualities of real materials to verify the colour adaptation effects during observations of material appearance. In our psychophysical experiments, three different illumination conditions were prepared for assuming the complete chromatic adaptation. They were a standard condition, an incomplete chromatic adaptation, and no adaptation. Our results suggest that the constancy of perceptual appearance works for most perceptual qualities under different illumination conditions using the illuminants D65 and A. However, coldness perception was strongly affected by colour adaptation.

Keywords: *appearance, materials, perceptual qualities, surface perception, illumination*

INTRODUCTION

Humans observe real objects under various viewing conditions and judge the perceptual appearance of objects in everyday life. In recent years, many studies have widely discussed several approaches to analyse material appearance including the perception of material appearance in the fields of neuroscience and psychology and the reproduction of material appearance in engineering (especially in CG fields). In our previous study [1], we investigated the perceptual qualities of surface appearance using real materials and degraded images of the same materials. We constructed a real material dataset, as well as four image datasets by varying the chromaticity (colour vs. grey) and resolution (high vs. low) of the material images. We analysed the relationship between these perceptual qualities and the various types of image representation through psychophysical experiments. Our results revealed that the representation method of some materials affected their perceptual qualities. However, our previous experiments were conducted under only fixed D65 local illuminant. In this study, we further investigate the perceptual appearance qualities of real materials by conducting psychophysical experiments under different colour illuminations to verify the colour adaptation effects during observations.

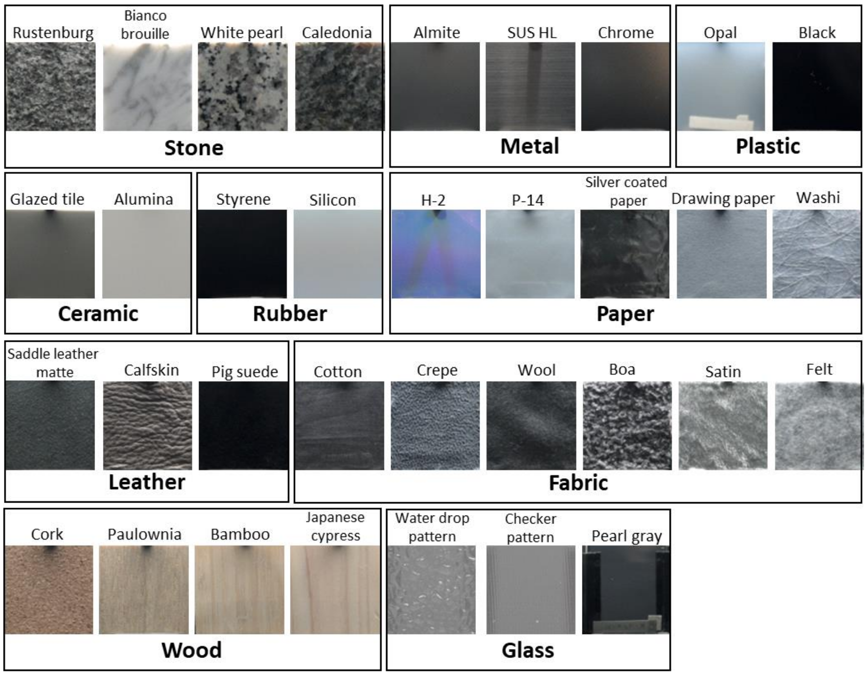


Figure 1: Experimental stimuli.

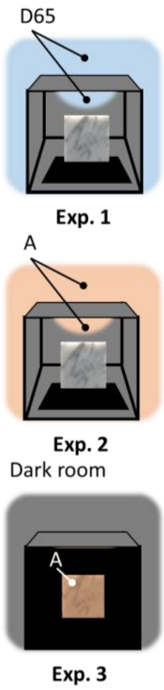


Figure 2: Experimental conditions.

EXPERIMENT

We used a dataset of 34 real materials comprising 10 material categories (stone, metal, glass, plastic, leather, fabric, paper, wood, ceramic, and rubber) to cover a wide range of appearances for each material, as shown in Fig. 1. The observer evaluated eight perceptual appearance qualities (glossiness, transparency, colourfulness, roughness, hardness, coldness, naturalness, and prettiness) using a 6-point scale (1: minimum, 6: maximum) under different illumination conditions. The definitions of the eight perceptual appearance qualities and the evaluation method of the experiment followed that of Fleming et al. [2]. As shown in Fig. 2, the experimental conditions were of three types, as follows:

Exp. 1. The stimuli were set under global and local illumination of standard illuminant D65.

Exp. 2. The stimuli were set under global and local illumination of standard illuminant A.

Exp. 3. The stimuli were locally illuminated by standard illuminant A, which was surrounded by the observation window with matte black paper in a darkroom.

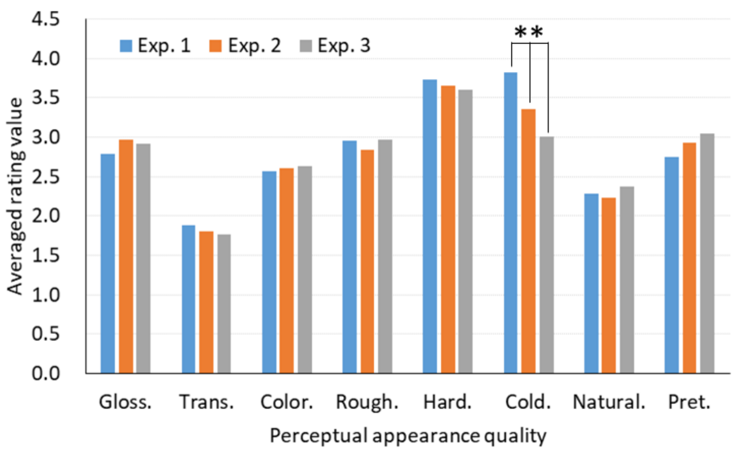
In our experiment, we used two types of illuminations—ceiling illumination and partial illumination—in a viewing box as global illumination and local illumination, respectively. The observers adapted to the ambient lighting colour in conditions 1 and 2, but in condition 3, the colour adaptation effect was avoided by controlling the observation time. These illumination conditions were prepared for assuming the perfect illumination adaptation as a standard condition, an incompleteness illumination adaptation, and no adaptation, for conditions 1, 2, and 3, respectively. The luminance of incident light to the stimulus surface was the same—140 cd/m^2—among all conditions.

RESULTS AND DISCUSSION

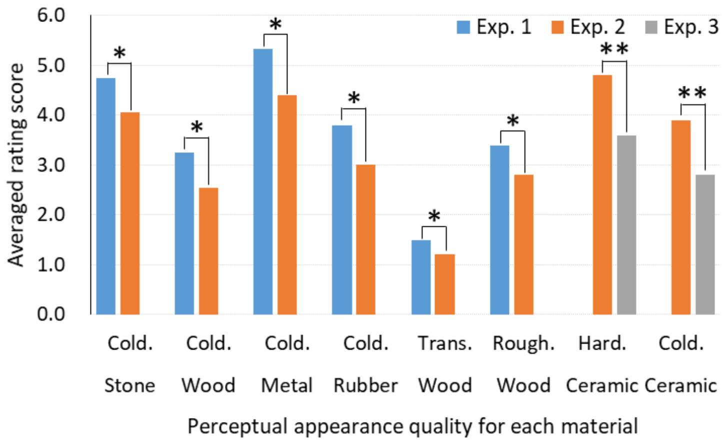
We selected observers who had high reproducibility in a preliminary experiment. Five observers participated in our experiments, all of whom were Japanese students with normal colour vision and eyesight. Figure 3(a) shows the averaged rating score for each perceptual quality for all materials. The results indicate that except for the quality "coldness", the perceptual appearance scores showed no significant difference among the three illuminations. The perceptual appearance quality of "coldness" among the three illumination conditions was significantly different; the averaged rating score was 3.8 for Exp. 1, 3.4 for Exp. 2, and 3.0 for Exp. 3 (**: $p < 0.01$). This result suggests that the constancy of perceptual appearance works for most perceptual qualities under different illumination conditions using the illuminants D65 and A. However, "coldness" perception was strongly affected by colour adaptation. Furthermore, as shown in Fig. 3(b), the significant difference of averaged rating scores for each material category was analysed. In the comparison of results between Exp. 1 and Exp. 2, coldness for four material categories (stone, wood, metal, and ceramic) and transparency and roughness for woods decreased with significant difference (*: $p < 0.05$). In addition, the results of hardness and coldness for ceramics showed a larger significant difference (**: $p < 0.01$). These findings reveal that the perceptual appearance quality evaluations of coldness for wood and ceramic might be affected by the illumination adaptation.

CONCLUSION

In this study, by conducting psychophysical experiments under different colour illuminations, we investigated the perceptual appearance qualities (e.g., glossiness, transparency, and roughness) of real materials to verify the colour adaptation effects during observations. Three different illumination conditions were prepared for assuming the complete chromatic adaptation: a standard condition, an incomplete chromatic adaptation, and no adaptation. Our results suggested that the constancy of perceptual appearance works for most perceptual qualities under different illumination conditions using the illuminants D65 and A. However, "coldness" perception was strongly affected by colour adaptation.



(a) Total.



(b) Each category with significant difference.

Figure 3: Averaged rating score for each perceptual quality.

ACKNOWLEDGMENTS

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Metallic Diffuse or Specular Inter-Reflections of Light and Spectral Multiplication for Accurate Rendering

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ABSTRACT

The reflection properties of polished metallic materials are responsible for gloss or glare effects. Unpolished metallic surfaces never cause such uncomfortable sensations. It appears that the physical process of reflection of light by metallic surfaces, in diffuse or specular mode, leads to a fast brain analysis allowing us to understand what kind of material is producing such a visual effect. That enrichment is caused by the addition of the successive spectral powers of the reflection spectrum to the first reflected light from the surface. The multiple reflections of light increase, by a darkening effect acting on colour and shininess. We present, in a prospective way, a set of demonstrative examples, taken in a real environment and produced by spectral simulations.

Keywords: *Metal, radiative transfer, specular reflection, rendering*

INTRODUCTION

Metallic surfaces are from very ancient times used for their capabilities to produce an intense specular reflection when polished. The reflection properties permit to define gloss as well as visual comfort or at the contrary a glare effect. Unpolished metallic surfaces never cause such uncomfortable sensations. It appears that the physical process of reflection of light by metallic surfaces, in diffuse or specular mode, leads to a fast brain analysis allowing us to understand what kind of material is producing such a visual effect. The specular transportation of light from a metallic smooth surface to another part of itself permits to instantly understand the nature of that surface. Several level of successive reflections from the metallic surface over itself enrich the perceived radiance by the human eye. That enrichment is caused by the addition of the successive spectral powers of the reflection spectrum to the first reflected light from the surface. We show how the reflectance powers of the Fresnel factor R (≤ 1) are involved to contribute to the perceived radiance. It also appears for non-specular metallic surfaces, as unpolished surfaces, that the radiative transfer is described by diffuse inter-reflections and follow the same mechanism of colour enrichment but leading to a non-metallic aspect. Some examples are given, taken in the real world or produced by spectral simulation.

THEORETICAL ASPECTS

Looking at the computed images produced in the 80's we understand the challenges for displaying shapes and material appearances. The computations made by the rendering algorithms to render glass and metal started when Ray Tracing programs were launched and became popular. Later, the light transport theories, according to radiative transfer ones were applied in Computer Graphics for the rendering of diffuse and light emitting surfaces. Thus, radiative transfer theories led to "radiosity algorithms". The main problems were, to ensure the physical law of conservation of energy being satisfied, to spectrally formulate all computations before displaying the resulting image in RGB mode. Physically based rendering was born. The games technologies, using GPUs capabilities made possible the necessary algorithmic acceleration aiming real time rendering. Hybrid algorithms using ray tracing and radiosity increased the visual realism of 3D scenes. The spatial lighting distribution was also a challenge for rendering and maintaining the conservation energy law valid. Photon mapping algorithms and their several successive adaptations helped to obtain visually and physically satisfying images in rendering. Light and materials properties were enough controlled and assisted by optical measurements (spectrophotometry, laser profilometry, gonio-spectrophotometry, spectroscopic ellipsometry, etc.) to permit physically based rendering to be convincing and leading to the making of products according to the, now ancient, "WYSIWIG" expression (What You See Is What You Get) historically used for geometric properties and sufficiently visually satisfying images.

Let us consider a beam of light interacting with a metallic surface, say copper for example. Depending on the state of surface (cleaned, polished or not, etc.) the first back reflected light towards the viewer includes a specular reflection part and a diffuse part. Looking at a convex shape the specular part (Figure 1) of the backscattered light has mainly the colour of the light source then in the very closed region to that, a pinky-greyish appearance dominates.

Figure 1: Two metallic surfaces (copper) receiving light and showing the successive images of the specular peak (left) after several mainly specular reflections.

The reflected light reaching after the first bounce the same material with the same state of surface is lighted by the direct light source and that indirect reflected light modified by the metallic material depending on the local tangent plane to the material of the first surface acting as a new emitter of light. Due to a light diffraction mechanism by small irregularities on the surface (roughness) the Fresnel reflectance factors are attenuated. Also, as they depend on the incidence angles the reflected light is modified by a dumping factor, difficult to evaluate in real circumstances. The multiple interaction of light with metallic surfaces, in case of a unique metal, lead to the polynomial relationship defining the contributing radiance to the metallic perception of the material.

We can write this as: $R_{tot}(l) = a_0 R(l) + a_1 R^2(l) + a_2 R^3(l) + \ldots$ where "l" is the wavelength and the coefficients a_i are roughness and angular dependent according to the Fresnel formulas. These last Fresnel formulas require the knowledge of the complex indices of refraction of metallic materials (metals or alloys). We measured several complex indices of ordinary alloys, precious alloys used in jewellery, pure metals and metallic compounds as well as minerals. That accurate measurements were obtained by spectroscopic ellipsometry since year 2003. The spectral complex indices are then used in the Fresnel formulas are given in Figure 2 where the successive powers of the mean Fresnel factor R(l) for unpolarized light are drawn.

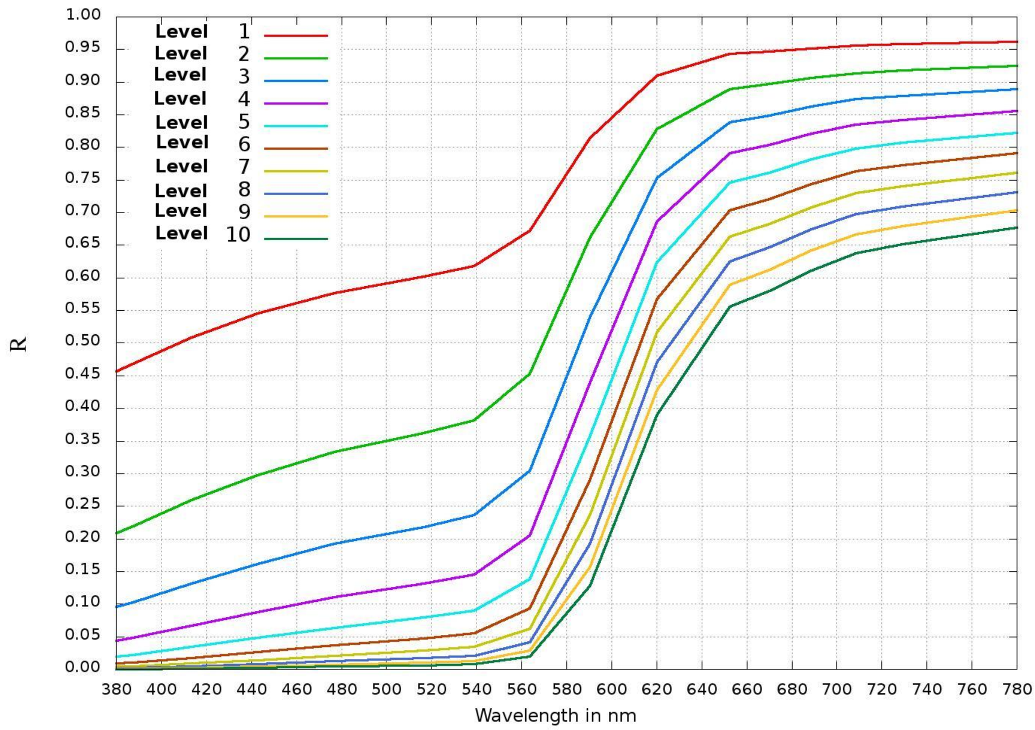

Figure 2: Successive powers of the mean Fresnel factor (unpolarized light) exhibiting the progressive transition towards deep red and intermediate brownish reds. Here is the extreme situation where the incident light is reflected at normal incidence as inside a laser cavity.

That extreme situation, in the ideal case of normal multiple reflections, gives the theoretical tendency. Multiple specular reflections are commonly visible in a lot of situations (have a look inside a saxophone pavilion, for example) and does not exceed 3 or 4 successive bounces. Notice that the angle of incidence over the surface, reduces the number of bounces while increasing the reflectance factor, except when close to the Brewster angle of reflection (between ~70° and 85° for metals).

INVERSE PROBLEM

As the lighting conditions are determinant for visual appearance of metallic surfaces and the material optical response depends on the polarization state of the incident and reflected light, some colleagues (Morel and al. 2006) attempted to reconstruct a 3D metallic surface relief. To do that, they created a particular setup using a digital camera equipped with a linear and rotating polarizer, a hemispherical diffusing white dome illuminated by a ring of white LEDs. That indirect and uniform lighting gives the metallic object a matte appearance showing weak variations in reflectance due to the polarized response of the metallic surface to that illuminating conditions. As previously demonstrated (Callet and Sève, 2001), a uniformly illuminated surface, polished or smooth, defined by its complex index of refraction and its characterized roughness has a reflectance factor much more important than the reflectance factor for normal incidence (Judd 1942). We then generalized the spectral calculations and computations proposed by Judd for use in the computer Graphics field to approximate the “ambient lighting”, historically defined with a rough approximation (a pure constant).

Figure 3: Pure copper plates exiting the electrolytic vat in a cypriot mine. The state of surface is highly rough and scatters the ambient light so the leftmost plate appears light pink. The other plates facing each other appear orange int such lighting conditions (the direct solar light is screened by the shed roof) and a greyish diffuse environment.

In real circumstances, this situation is encountered when a cloudy sky dominates leading the cast shadows of objects almost invisible. However, in these lighting conditions, the shininess of metallic convex polished surfaces is not obvious at all. A shiny appearance is then revealed for directional lighting and/or reflections of the environment. A lot of situations are very common with direct an diffuse lighting. A very rough and pure copper surface (Figure 3) illuminated without direct solar light intensely scatters the ambient light and appears slightly pinkish, if flat or convex.

When two similar plates, made of pure copper are facing each other, the light transport by multiple scattering (diffuse inter-reflections) tends to change the perceived colour by spectral enrichment. These parallel plates then appear orange. Except the shininess appearance, that colour is the same for multiple specular reflections as presented in Figure 1.

CONCLUSION

The theoretical behaviour of light interacting with metallic surfaces is well known but not enough used within the image analysis field of research. The Computer Graphics communities developed a set of models for light interaction and transport in diffuse or specular mode. It would be interesting to build a real scene and its 3D virtual equivalent with several optical interactions between surfaces for testing the shape extraction and recognition in very complex environments when multiple reflections are present. Later, transparent materials could be studied...We have presented here a brief proposal and intellectual framework for going further in some situations.

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Semiotic Colour Characters (SCC)

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ABSTRACT
Semiotic colour character (SCC) set is an alphabet for colour description and display. It is intended for the integration of colours as signs like any other sign in a text flow. We think that this approach is relevant when colour constitutes the substance of the textual information and not the form of it. Examples of uses include, inter alia, colour sample transmission, road signs and emoji. Given that the aim of this alphabet is to meet the needs of a large range of specialists in many different trades, such a project has to assemble like-minded individuals and potential contributors. That's why SCC is presented here in a very early stage of its development. It is not a norm, nor even a recommendation, it is just a draft.

Keywords: *semiotic, semantic, icons, Unicode, colour*

INTRODUCTION

Saying that colour is a universal language may sound like something poetic, or like a metaphor. But it is not a metaphor. Colour is a *sublanguage*, it is part of the innumerable languages in the world. The universality of colour and the diversity of its implementations is a basic acknowledgment that is impossible to circumvent if we want to perceive the relevance of Semiotic colour characters (SCC).

This work is not a scientific study in itself, it is merely a draft, a proposal to every person and organization who wants to contribute to this project of linguistic engineering in the field of colour and light. SCC is based on a lot of sources, most of which are very easily accessible. Its interest is not in the knowledge it brings to the community, but in the conviction that the universality of colour opens the way to a modern but universal alphabet, for modern *sublanguages* and data formats.

SCC is a set of signs that can be named icons or glyphs, depending on the *design* we consider, it is meant to be the least common multiple of any *sublanguages*. *Sublanguages* based on SCC are intended to emerge within an infinite set of human, technical or machine-readable languages and data formats. To get an idea of how big is the set of these languages, we have to explore some dimensions of the set of languages:

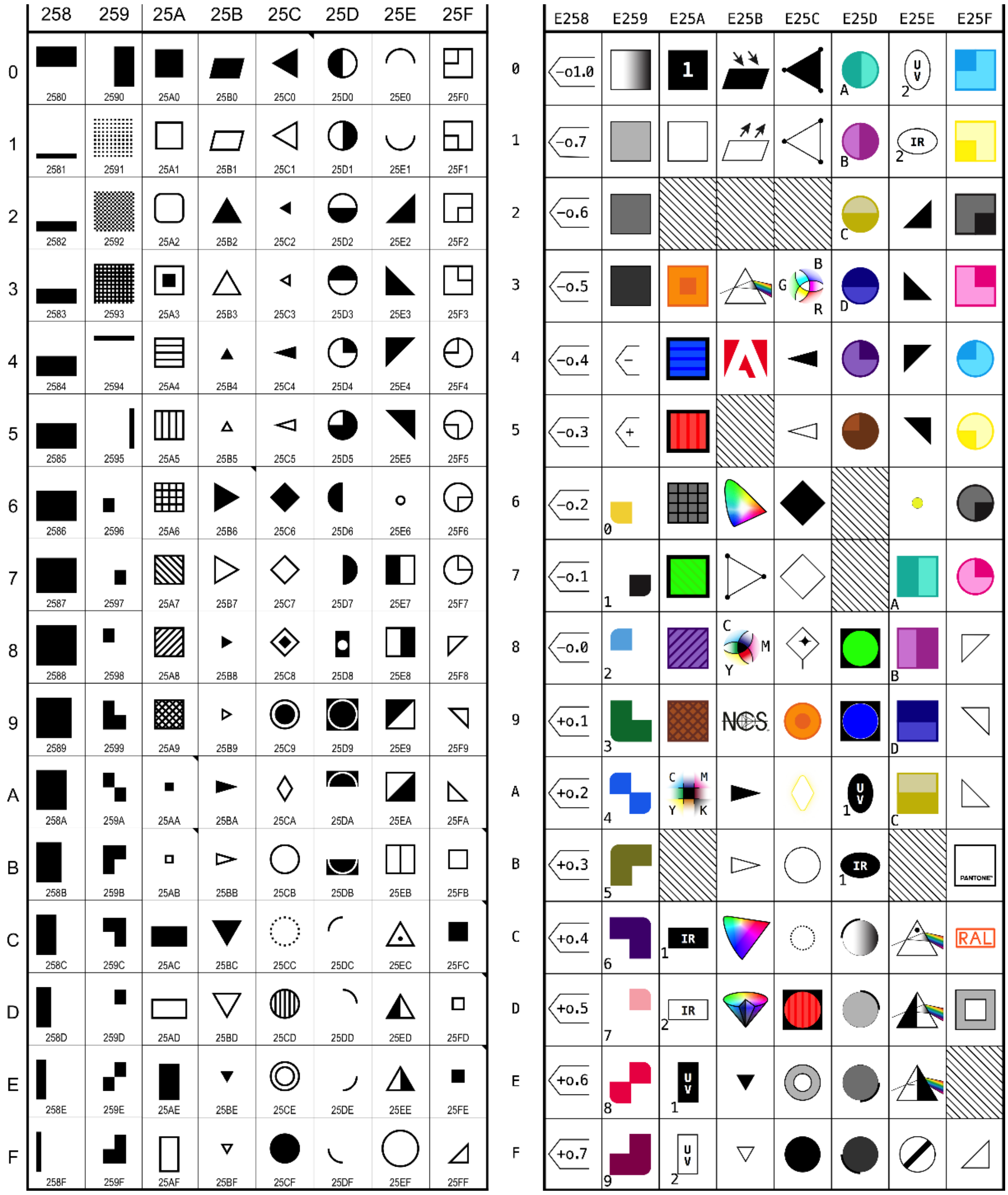

Figure 1: At left the existing Unicode glyphs, at right *SCC adjectives* represented by their icons

In human language, the simple word "red" can have many meanings, but even if it identifies a whole range of shadings, it is a concept by itself. Red colour can be normalized in different ways, for instance it is one of three dimensions of the RGB space. In heraldry, red is named "gules" but the meanings of these words are close enough to justify a unique concept within SCC. Just like the letter A in the latin alphabet, which is used in many languages in the world, and has a different phonetic meaning in English or in French.

However, in computer science there is an uppercase 'A' and a lower case 'a' and these letters are also part of both latin and cyrillic alphabets and therefore we can mention four characters for just one letter. In the same way, SCC codes RED STROKE and RED FILL as different characters, and proposes a different coding for the *adjective* / RED which, therefore, gives rise to four characters.

As we have already seen, colours can be described or displayed. They can also be implemented in different ways, when used by different trades, like printing, chemistry, physics, computer science and when understood by people from different cultures. Even if they involve different shading, they can merge into a unique character and change in meaning. But from the linguistic point of view, colour science can be reduced to a small set of basic concepts, to an alphabet, and that is the purpose of SCC.

THE FOUR DESIGNS, SCC AS A PROJECT

The Semiotic colour character set is a project which can only be seen as a system of four items named *designs*, which are:

1 *SCC meaning*, exposed in a request for comment for the computer community

2 *SCC icons* have to be implemented as fonts or pictures

3 *SCC adjectives* could be a proposal for Unicode and IS0 10'646

4 *SCC sublanguage design* will utilize the abilities of SCC

Each of them is a different work, but they only make sense if they are achieved together.

1. SCC re-uses a range of existing Unicode characters (geometric shapes U+2580 to U+25FF). SCC proposes a new *meaning* for these characters that is trivial in computer science and can usually take the form of a request for comments (RFC). As a result, authors of computer language, formats and programs will be encouraged to use these characters, and graphically their glyphs, when they describe a colour.

2. Icons are proposed for a better understanding of these *meanings*, because they are more comprehensive than geometric shapes. These icons could be implemented by a font or simple images. *SCC icons* could be used everywhere, not only in an electronic environment. They are based on a systematic unification of existing traditions and practices. Among them, we can number the following:

- displaying (additive colour system)
- printing (subtractive colour system)
- semiotics, for instance: heraldry, typography, traffic signs, computer icons

3. *Adjectives* should be proposed for normalization in the universal character set named Unicode (ISO 10'646). The *SCC adjectives* will be a sort of compiled version of SCC graphical characters, they are *designed* to display the colour rather than describe them. Thus, colour and not only its description will be encoded as text. As a result, colour will be accepted as a language in the same way as Greek, Chinese, Byzantine musical notation and Mathematical formulas.

4. SCC cannot become popular beneath a threshold of concrete implementations. SCC is definitely not a commercial project, it only belongs to the culture of colour. The community needs some concrete examples to start to feel the benefits. Thus, graphic results are also needed to complete SCC as a project, on the same way as every alphabet needs the existence of words forming texts to exist in and of itself as an alphabet. As they do for words that are listed in dictionaries and are standard for a specific language, operating systems and applications have to be enhanced with some new services and let the final user enjoy the benefits, that is, exchange

information in colour language. Below, we will give some examples of colour sign displays. While the combinations allowed by SCC are unlimited, forming these combinations is barely affordable for end users who would rather use combinations prepared by language designers. That is why *sublanguages design* is a part of the whole SCC project.

WHY DOES IT NOT YET EXIST?

Colour is one of the most emotional languages in the world. We can like a colour or be disgusted by it. This emotional component makes us forget that colour can communicate straightforward factual information, colour is part of semantics. But the doxa tends to restrict colour to the esthetic, to the form of information, more than to the substance.

The best illustration of this fact is that, soon after the occurrence of the Web, the World Wide Web Consortium started to develop Cascading Style Sheets (CSS) which were invented especially to separate the substance of a web page (written in HTML) from a separate file (written in CSS) describing its form and specifically the different colours of the web page. This way of operating is consistent with "Semantic Web" and with the principles of Unicode which excludes text formatting. Far from wanting to criticize this excellent choice, SCC (which is a sort of inversion of CSS) aims to provide the opposite.

There are many cases when colour is definitely not the form of the information but its substance. That is why we insist on saying that colour is a language. This is the only innovation of SCC; all the rest is a recovery of existing principles and forms.

Since Unicode Consortium has heard of the development of SCC (in March 2018), new colour characters have been proposed for Emoji, what proves that there is at least some interest for the concept.

WHAT IS MEANT BY "SEMIOTIC"?

SCC is a set of signs, but these signs can also combine to form new multicolour signs by which colour plays a semantic role and not an aesthetic one, and by which colour is a sign by itself. Note that the red square modifies the stroke and the blue circle modifies the filling.

Figure 2: U+29B8 SCC+E25A5 SCC+E25D9, forming the european No Parking sign

In the next example, the filling surrounds the triangle:

Figure 3: U+25B2 SCC+E25C9 SCC+E25A4, the international distinctive sign of civil defense

In the last example, four characters are needed to express a special shading of colour. Several signs combine to form a colour which is a sign by itself and fully part of the semantic of the information to transmit, because this is a colour sample.

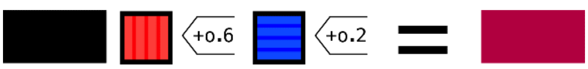

Figure 4: U+25AC SCC+E25A5 SCC+E258E SCC+E25A4 SCC+E258A, a colour sample

COLOUR SAMPLE TRANSMISSION

The last above example gives us the opportunity to illustrate what is practically impossible to do with electronic devices today. Let's imagine an ordinary situation:

Mrs. Smith sends her husband, Mr. Smith, to the store to buy new curtains for the living room. Mr. Smith is spoilt by the choice and hesitates between several colours. He wants to ask the opinion of his wife who has a direct view onto the window of the living room and has a good idea of which hues should match the sofa and other furniture. Sending a colour sample is a real problem. One could:

1, take some physical samples, bring them home and return back to the store once the decision has been taken,

2, take a picture of the curtains so that Mrs. Smith can immediately see their colour, without moving between store and home,

3, use a QR code affixed on each curtain type linked to a specialized colour sampling application which will be prospectively downloaded by the spouses, and which will transmit the exact shading of the colour.

These three solutions each have their particular disadvantages:

1. Back and forth to the store considerably slows down the decision-making.
2. Pictures taken by a camera do not transmit the colour faithfully enough to be used as a sample of them.
3. Installing a specialized application is the best solution but it is very demanding: a set up will be needed on both devices as well as complicated handling in order to transmit the data so that this solution becomes the worse in practice.

The advantage of a solution that is integrated to the text coding and directly managed by the operating system is that the information, which the husband will copy using QR code, will not need any specialized application and can be transmitted through the preferred messenger of the couple, received and interpreted without ambiguity by the spouse, the colour fidelity being guaranteed by the operating system as a basic function of her device. This does not ban the use of specialized applications to make better use of this information, rather, since the applications will always base themselves on the same alphabet and compatible system services, they will be able to exchange this information easily and faithfully.

SCC IN EMOJI

SCC could be used to extend emoji using character combinations. Emoji already use character combination to code one graphical symbol, so the practice is not new, but using an *adjective* instead of a graphical character for combination is a better choice, since *adjectives* have to be simply ignored by systems that cannot deal with them, contrary to the case of graphical characters, that make an emoji that you receive totally unintelligible when your smartphone is not the latest model. With SCC, if an environment is not compatible, it simply ignores the *adjective*, which is an excellent graphical approach.

Figure 5: how to put on a traffic light

Note how simple SCC is in practice. Once again, SCC are not intended for colouring, but for semiotic, therefore, semantic precision. The yellow jersey awarded to the winner of the Tour de France (bicycle race) is not only a yellow coloured T-shirt, as an award, it has a special semantic, it is a stand-alone graphical character, but it could be coded like a combination of two characters:

Figure 6: U+1F455 t-shirt with SCC+E25F5 yellow fill

CONCLUSION

This paper contains approximately 1/6 of the information from the complete description of SCC. Since the project is still a draft, it could receive substantial changes. Every person and organization who aim to contribute, are kindly invited to present themselves during the AIC Interim Meeting'18, in Lisbon, Portugal.

ACKNOWLEDGEMENTS

Thanks to Habib Saliou-Diallo, Olga Englert, Anna Drozdova

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colour & human comfort

Colourization of Dichromatic Images

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ABSTRACT

This paper explores the colour information dichromatic vision provides in terms of its potential for colourization. Given a greyscale image as input, colourization generates an RGB image as output. Since colourization works well for luminance images, how well they might work for dichromatic images? Dichromatic images are colourized using a modification of the colourization method of Iizuka et al. (Proc. SIGGRAPH 2016, 35(4):110:1-110:11). In particular, an sRGB image is converted to cone LMS and M is discarded to yield a LS image. During training, the colourization neural network is provided LS images and their corresponding LMS images, and it adjusts its weights so that M is predicted from the L and S. One does not easily recognize that a colourized dichromatic image is, in fact, based on only L and S, and is not a regular full-colour image. This is stark contrast to the dichromatic simulations of Brettel et al. (Brettel, Viénot, Mollon, *JOSA A* 14, 2647-2655, 1997).

Keywords: *Colour blindness, dichromat, computational colour vision, colourization.*

INTRODUCTION

What it is like to be colour blind? What colours do dichromats see? How much 'colour' is really missing from a dichromats experience. Since it has been reported that many people do not realize they are colour blind until they are many years old, perhaps the difference is not so significant. Of course, we really can never know what another person experiences, but we can explore what colour information dichromatic vision provides. In recent years, many colourization methods have been described in the computer vision literature. Given only a greyscale (i.e., luminance) image, these computer-based colourization methods generate a colour image with very believable colours. Colourization methods are generally based on 'deep learning' the connection between luminance, the context, and probable colour. It appears they encode knowledge about the world such as clear sky is blue, clouds are grey, beaches are a sandy colour, forests and grass are green, and so forth. Since colourization works for luminance images, we explore how well they might work for dichromatic images.

The results of colourizing dichromatic images can be expected to give us more insight into what colour information is present, as well as missing, for the dichromat at a more experiential level than the standard statements that deuteranopes—observers lacking M cones—cannot distinguish some reds and greens from one another. Brettel et al. [1]developed a simulation of dichromatic vision based on projecting the given LMS stimulus onto a reduced stimulus surface defined by the neutral axis along with the LMS locations of the monochromatic stimuli that are perceived as the same hue by normal trichromats and dichromats. Psychophysical experiments with dichromatic observers validate their method. Although the full colour image and its dichromatic simulation look quite different to the trichromatic observer, they appear indistinguishable to the dichromatic observer. See Figure 1 (left and middle). This example of the dichromatic simulation was produced using Vischeck [7], a web-based implementation of the Brettel et al. [1]algorithm. Note that the Vischeck result only roughly approximates the true Brettel et al. result since it requires the image to be displayed on a calibrated CRT monitor, not an uncalibrated LCD display.

Figure 1: (Left) input image; (Middle) dichromatic simulation that appears the same to the dichromat as the input image when viewed on a calibrated display; (Right) colourized LS image. The dichromatic simulation lacks the green of the apple and the reds in the background; however, the colourization result shows that much of the colour information can still be correctly inferred (but note the grey suit and tie) from the LS input.

BACKGROUND

Well prior to the current interest within the computer vision community concerning the colourization of greyscale images, Cardei [2] extrapolated RB images into RGB images using three different strategies: a very small (by today's standards) 3-layer, 9-neuron neural network, linear regression and polynomial regression. He reported quite good results, with the neural network and polynomial regression methods leading to similar errors in the prediction of G from RB input. By comparison, modern colourization networks use 30 layers with 1,500,000 parameters. These colourization strategies are based on deep convolutional neural networks [6], which have been shown to be able to learn complex mappings from large amounts of training data. In particular, Iizuka et al. [4] showed that deep Convolutional Neural Networks colourize greyscale images very well. However, their proposed model is very large and takes weeks to train and hundreds of megabytes to store. Johnson et al. [5] proposed an alternative network structure that was originally developed for transferring the style of one image to another. For dichromatic colourization, we use the basic method of Iizuka et al. but modify it to make use of the structure that Johnson et al. proposed.

EXPERIMENTS

Training and testing a neural network require a large number of images. For this we use the Microsoft COCO [3] image dataset, which contains images in sRGB format. The first step is to convert the sRGB data to LMS (i.e., cone response space). The non-linear sRGB input is converted first to linear XYZ (CIE XYZ space) according to the sRGB standard, and then from XYZ to LMS cone space using the Hunter-Pointer-Estevez transformation matrix. To simulate a deuteranope, the M channel is discarded, yielding a 2-channel, LS image.

The network structure is outlined in Figure 2, with the details listed in Table 1. A LS image is input and then processed by the deep colourization model, which is composed of an encoder, shave blocks and a decoder. The corresponding M channel is predicted from the patterns found in the training data.

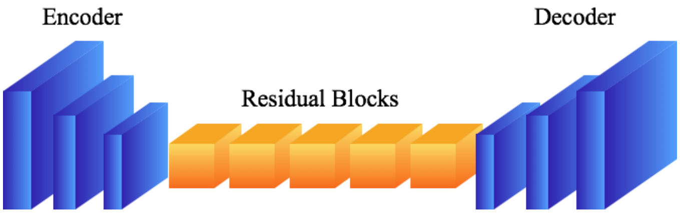

Figure 2: Blue indicates a composition of a convolutional (conv) layer, a batch normalization (BN) layer, and a rectified linear unit (ReLU). Orange indicates a block that includes a shave layer in parallel to a composite Conv-BN-ReLU-Conv-BN convolutional layer. The results from the parallel paths are then summed.

Encode

type	kernel	stride	output
conv	9x9	1x1	32
conv	3x3	3x3	64
conv	3x3	3x3	128

Residual Block

type	kernel	stride	output
conv	3x3	1x1	128
conv	3x3	1x1	128
residual	-	-	128
sum	-	-	128

Decode

type	kernel	stride	output
deconv	3x3	2x2	64
deconv	3x3	2x2	32
conv	9x9	1x1	1

Table 1: Specifications of the different components used in the dichromatic-colourization network. Kernel indicates the size of the convolution (conv) kernel. Stride controls the subsampling of the input data. Output refers to the number of convolution filters of the given size and stride used in the respective convolutional layer.

The network training involves inputting 83K LS images from the COCO dataset along with their corresponding M-channel pixel values. During training, network's weights are adjusted so that M is predicted from the L and S. The training converges to a low average ‘loss’ measured by the L2 norm in LMS space. The network’s LMS output is then converted back to sRGB for display. The remaining COCO images are used for testing. Figure 3 shows some typical examples.

RESULTS AND DISCUSSION

As is apparent from the right-hand column of Figure 3, the colourization results are surprisingly believable. In other words, one does not immediately recognize that a colourized dichromatic image is, in fact, 'dichromatic' (i.e., in the sense that it is derived from only two channels of colour information), and not a regular full-colour image. While it is impossible to draw a formal conclusion from such examples about the nature of dichromatic colour perception, it does indicate that the dichromatic images do contain more colour information that might be expected from trichromatic viewing of the Brettel et al. simulations. As might be anticipated from the fact that the L and M cone sensitivity functions significantly overlap, much of the information is there, it simply has to be extracted computationally. Whether or not dichromats do extract such information is a question for further study.

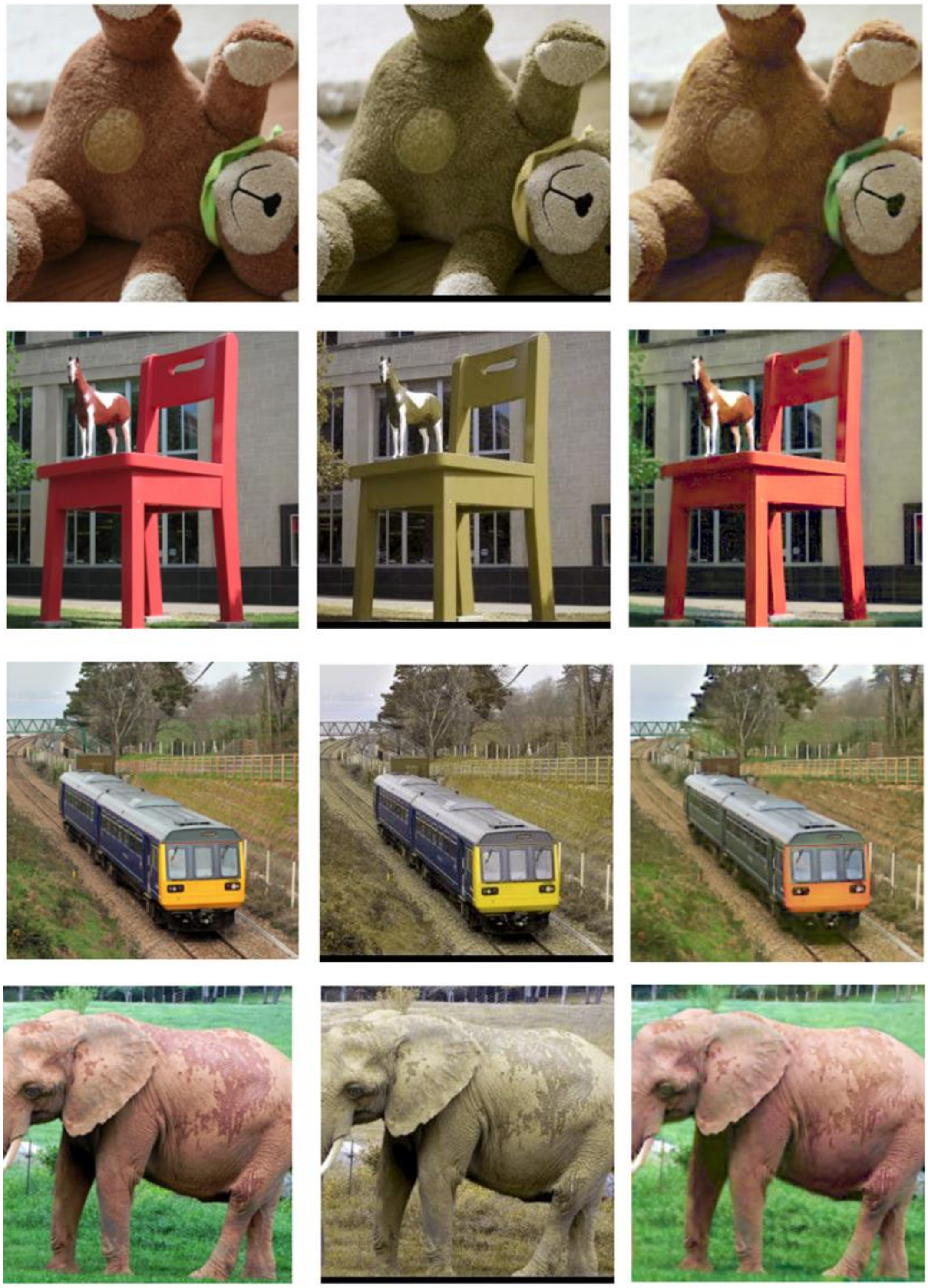

Figure 3: Left column contains the sRGB input images; Middle column are the Vischeck corresponding dichromatic simulation results; Right column are the LS to LMS colourization results.

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Colour Constancy by Machine Learning using Physics Based Rendering Images

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ABSTRACT
The colour constancy is a human visual characteristic that can correctly recognize the colours of objects even if the colour of the illumination light changes, but its mechanism has not been elucidated. Convolutional Neural Networks (CNN) simulate the structure of human receptive field and human visual cortex. It is expected that CNN helps clarify the mechanism of human visual systems by reproducing it on CNN. Therefore, in this research we attempt to construct a model that reproduces the colour constancy with CNN. CG images in which the colours of the light sources are randomly set are generated by physically based rendering. We use paired CG images of same objects lighted by coloured and white light source as input and training images. Then, we evaluate the model by subjective evaluation experiment.

Keywords: *Colour constancy, Physics based rendering, Machine learning, Convolutional Neural Network, Generative adversarial network*

INTRODUCTION
The colour constancy is a phenomenon in which we can correctly perceive the colour of an object even if the colour of the illumination light changes. Light reaching the visual system from the object is the light that has been reflected by the spectral reflectance of the object by applying the spectral distribution of the illumination light. When the spectral distribution of the illumination light changes, the spectral distribution of the light reaching the eye also changes, but the colour of the object perceived by us does not change. Therefore, it is conceivable that there exists a mechanism to compensate for this change in the visual system. The auto white balance of the camera corrects the colour tone of the acquired image according to the scene. It is conceivable that by applying the mechanism of human colour constancy, correction with colour perceived by human beings can

be realized. In this research, we attempt to reproduce the colour constancy mechanism by Convolutional Neural Network (CNN). CNN is a model of the structure of human visual cortex. This research also deals with a model that uses generative adversarial networks (GAN) together in the field of image generation (Goodfellow 2014). GAN consists of Generator and Discriminator. Generator learns to trick Discriminator, and Discriminator learns to see the fake generation result of Generator. Images generated by the GAN can obtain clearer results (Radford 2015). pix2pix can realize various tasks such as colouring, generating images of roads and buildings from label images, and generating map images from aerial photographs (Isola 2016). By reproducing and analysing the colour constancy mechanism in CNN, it is conceivable that useful information can be obtained for elucidation of the mechanism. Assume that the scene before the colour constancy is applied as the image of the coloured light source and assume that the scene corrected to the correct colour by the colour constancy is the image of the white light source. When a coloured light source image is inputted to CNN, a white light source image is outputted. By learning like this we reproduce the colour constancy. Therefore, many images are required for learning, but it is difficult to collect various scene images with light source colours changed in the real world. Therefore, by physically based rendering, a large amount of CG images under different light sources approximating the real world are generated and used as learning data.

THEORY

In this section, we describe various settings in physically based rendering and construction of colour homeostatic neural networks.

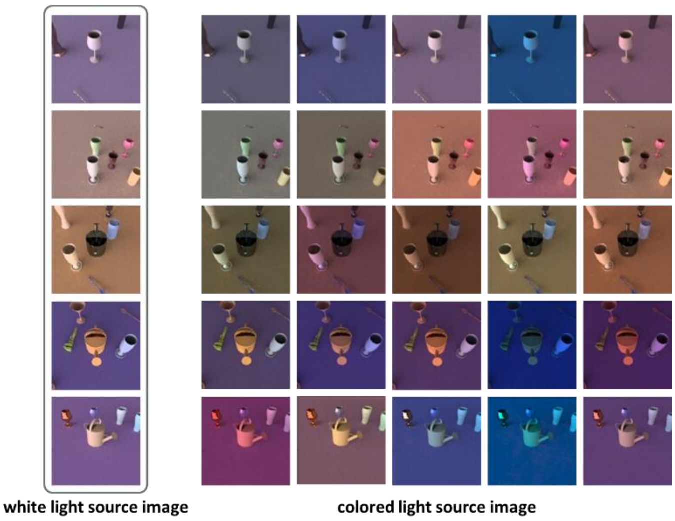

Figure 1: Examples of the generated CG image.

In this research, we generate the learning CG image using Physically Based Rendering (PBRT) (Pharr 2016) which is a renderer based on physical theories. We prepared 20 kinds of 3D model objects such as can, glass, and cup. The objects are given surface parameters of material and reflectance factors. The materials are randomly set from 5 kinds of metals, mirrors, plastics, mud and uber which PBRT provides as standard. The reflectance factors such as mirror specular reflectance, diffuse reflectance and surface roughness of the material are also set randomly. The colours of the object depend on spectral reflectance of the objects surfaces. The parameters of objects are set for each scene. Several different CG images are rendering for each scene by changing the light source. The spectral distributions of the coloured light sources are set randomly, and the white light source is set to blackbody radiation of 6500K. The examples of the generated CG images are shown in figure 1.

We use pix2pix for construct a colour constancy neural network. The approach uses an auto encoder called U-net is used for that performs dimensional compression. The input and output images are changed to 3 channels of RGB to apply the network. The structure of the network is shown in Figure 2.

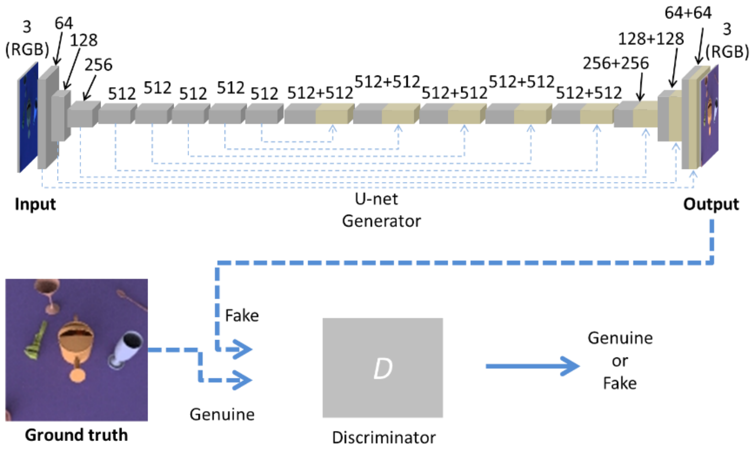

Figure 2: The structure of the colour constancy neural network.

We quantitatively evaluate a difference between the output image of the network when inputting an image of coloured light source and the image of white light source as the grand truth. The images are converted into the CIE Lab colour space, and pixel values of *a** and *b** are used to evaluation by Root Mean Squared Error (RMSE). Equation (1) shows the expression of RMSE.

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\frac{1}{2}\sum_{k=\{a*,b*\}}^{2}(x_{ik} - y_{ik})^2} \qquad (1)$$

x_{ik} is the pixel value of the grand truth image, y_{ik} is the pixel value of the output image, and N is the number of pixel. RMSE always has a positive value and it becomes smaller with decreasing the error.

EXPERIMENT

In this section, we describe evaluation experiments of learned networks and subjective evaluation experiments.

The colour constancy neural network is learned using 4000 set of 100 × 100 pixels training image, with batch size set to 1, step size α is 0.00023 and iteration times is 16,500. The training parameters are determined empirically to the RSME value became smaller.

Evaluation experiments on learned networks were conducted by inputting unknown CG images and actual photographic images. We input unknown CG images which were not used for learning to the learned network and evaluated whether the colour constancy could be realized. When the actual photographic image took by a single lens reflex camera, objects were arranged in a small studio in the dark room, and the light source was a variable colour LED. One light source of the variable colour LED was set as a white light source and adjusted by the manual white balance of the camera to obtain a white light source image. We took coloured light source image using the camera setting when took the white light source image. In the same way as input experiments of unknown CG images, actual photographic images were input to the learned network and evaluated whether the colour constancy could be realized.

Subjective evaluation experiments compare the performance of the colour constancy neural network with the human colour constancy. An image is presented on the display calibrated in the darkroom, and the experiment participant answers the colour of the specified object in the image from the eleven categorical colours composed of white, red, green, yellow, blue, brown, orange, purple, pink, ash and black (Berlin 1969). We present the coloured light source CG image, the white light source (grand truth) CG image and the output image of the colour constancy neural network of the same scene and ask to answer the apparent colour of the same designated object from the categorical colours. We call each answer as output colour of human colour constancy, colour of grand truth and output colour of the colour constancy neural network. By comparing these answers, we evaluate the difference between human colour constancy and the colour constancy neural network.

RESULTS AND DISCUSSION

In this chapter, we describe the results of the experiment and the discussion.

In the evaluation experiment on the learned network, the result image when inputting an unknown CG image, the local CIE Lab value and ΔE^*_{ab} between the grand truth and the output are shown in Figure 3.

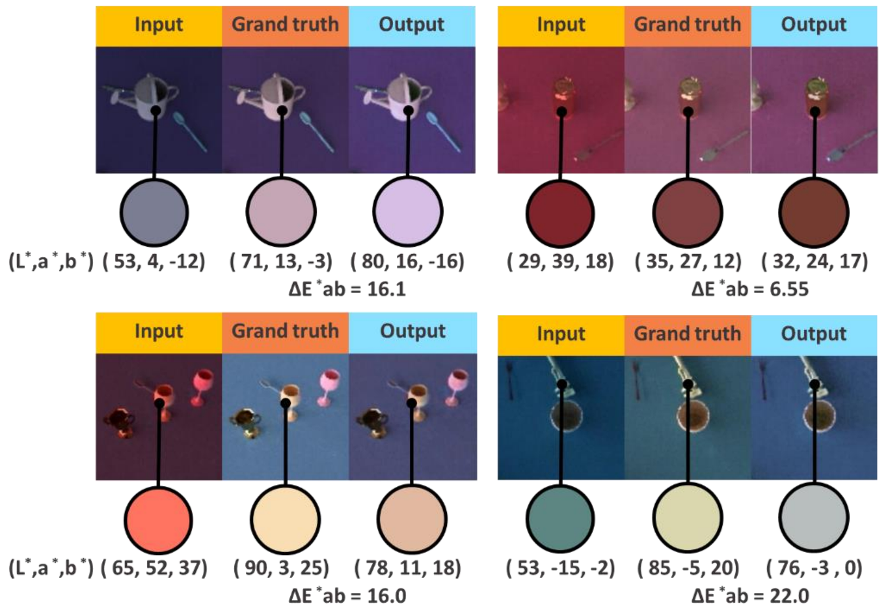

Figure 3: The result when inputting unknown CG images.

Sprinkling can (upper left in the Figure 3) has been corrected from grey to pink, and the cup (lower left in the Figure 3) has been corrected to a colour close to the grand truth image from orange to light brown. From these results, it is considered that colour constancy is realized. There is also a set of images that corrects the colour of highlights of gloss to white. It seems that the estimation and correction of the light source colour are done by highlight.

In the evaluation experiment on the learned network, the result image when inputting the actual photographic image, the local CIE Lab value and ΔE^*_{ab} between grand truth and output is shown in Figure 4.

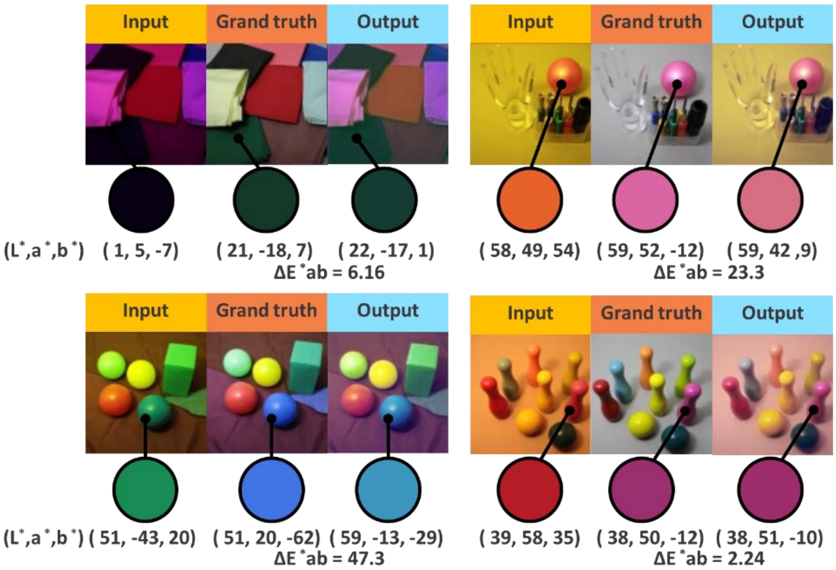

Figure 4: The result when inputting actual photographic images.

As shown in the Figure 4, it was confirmed that colour constancy could be realized locally. In many cases, the correction was weak as compared with the output result of the unknown CG image, such as the colour of the light source remaining. It is thought that the saturation of the real photographed image was higher than that of the learning CG image and it was not able to deal with the correction of the large saturation as the reason for the weak correction.

We compiled and analysed responses from subjective evaluation experiments. It was 38.9% that matched with output colour of human colour constancy and colour of grand truth. From this result, there was a possibility that human colour constancy would not work for CG images generated in this research. However, it was 57.8% that matched with output colour of colour constancy neural network and colour of grand truth. Even with such a CG image, it was confirmed that the colour constancy could be realized to some extent by the network. Finally, the result of human colour constancy working correctly and matching with the answer of output colour of colour constancy neural network was 78.6%. Therefore, we found that the network of this research can reproduce human colour constancy.

CONCLUSION

In this research, we aimed to realize human colour constancy on computer with CNN and GAN. The scene before colour constancy was applied was assumed as an image of a coloured light source and the scene converted to the correct colour by the colour constancy was assumed to be the image of the white light source. We constructed colour constancy neural network by learning using CG image of physically based rendering. In experiments, colour constancy was confirmed in many cases in experiments on CG images. In the future, we will construct a network with further high reproducibility of human colour constancy according to improving the learning image and we aim to clarify the mechanism of colour constancy by using analysing or visualization.

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Multispectral Measurement System of Oil Paintings for Digital Archiving

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ABSTRACT

The present paper proposes an improved multispectral measurement system for estimating the detailed characteristics of an art painting surface. The proposed multispectral measurement system consists of a multispectral camera and nine light sources, which are fixed to a device framed with a plastic-coated steel pipe and a joint. By fixing the camera and light source, the proposed measuring system can reduce the work space, improve work efficiency and work stability. Moreover, the number of contacts with the camera decreases dramatically by realizing remote camera control. We describe a method for digital archiving of art paintings based the present multispectral measuring system. The feasibility of the proposed method is shown on experiments using real painting objects.

Keywords: *Digital archiving, multispectral imaging systems, Painting measuring system, Colour image rendering*

INTRODUCTION

In recent years, a digital archive for preserving the historical and artistic heritage in the digital image information has attracted attention. In order to preserve paintings digitally, information on the painting surface must be precisely recorded, and the technology of multispectral imaging is quite effective (Miyake et al. 1999). Since a multispectral imaging system has high wavelength resolution compared with colour cameras, colorimetric accuracy in the acquired image is certainly improved (Imai and Berns 1999). Therefore, the authors so far have developed multispectral imaging systems for digital archiving of art paintings (Tominaga and Tanaka 2008, Nishi et al. 2017).

However, our previous measurement methods have several problems. In our method, the camera is fixed and the light source is moved in a plurality of directions to acquire a painting image. This light source is composed of a wagon and a slide projector, and it is relatively large. Therefore, the first problem is that a sufficiently wide space is required for acquiring painting images. The second problem is that the camera must be frequently touched to change the shutter speed and replace the filter during the measurement. Moreover, these operations such as light source movement and camera manipulation must be performed in the darkroom, therefore it is also a problem that measurement failure tend to occur easily.

The present paper proposes an improved multispectral measurement system for estimating the detailed characteristics of an art painting surface. By fixing the camera and light source, the proposed measuring system can reduce the work space, improve work efficiency and work stability. Moreover, the number of contacts with the camera decreases dramatically by realizing remote camera control.

THEORY

Multispectral Measuring System

The proposed multispectral measuring system consists of RGB camera and nine light sources. The Canon RGB camera used for the measurement has a resolution of 3072 × 2048 pixels and a 12-bit colour depth. For multispectral measuring, we prepared two additional colour filters. Combining these two different transmittances with the spectral sensitivity of the camera, different sets of trichromatic spectral sensitivity functions are obtained. Therefore, integrating two sets of modified trichromatic spectral sensitivities, the measurement system with six spectral bands in the visible wavelength region can be constructed. These camera and light sources are fixed to a device framed with a plastic-coated steel pipe and a joint. Figure 1 shows the proposed multispectral measuring system. The camera is fixed vertically to a painting object. The light source is installed in eight lights in the horizontal direction (azimuth interval of 45 degrees) and one light in the vertical direction. The light source is installed around the painting in eight directions (azimuth interval of 45 degrees) and one direction in the upper part of a painting object. The size of the measuring system is about 70 cm × 70 cm × 60 cm, which makes it possible to work in a very small space as compared with the conventional method.

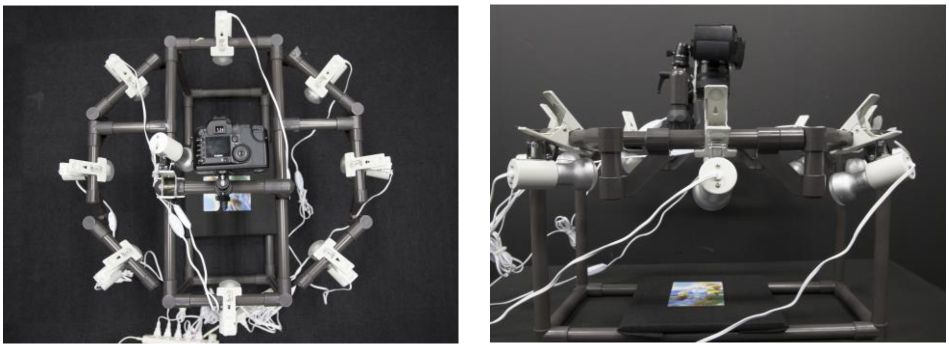

Figure 1: Measuring system (left: top view, right: side view).

In this measuring system, remote operation of the camera is realized. We used gPhoto2 for remote operation of the camera. Remote operation of the camera and fixation of the light source have made it possible to drastically change the measuring procedure of the conventional method.

As a result, the number of contacts of the camera is greatly reduced, and in this measuring system it is only one time for filter replacement.

Digital Archiving of Art Paintings

We describe a method for digital archiving of art paintings based the present measuring system. The surface reflection of an oil painting includes the specular reflection or gloss. Therefore, the camera output for the painting surface is composed of a diffused reflection and specular reflection. The reflection properties, the surface-normal vector and the surface-spectral reflectance are estimated from the diffuse reflection component, and the reflection model parameters are estimated from the specular component. To estimate the surface-spectral reflectance, the camera output is described as a model:

$$\rho_k = \sum_i S(\lambda_i)E(\lambda_i)R_k(\lambda_i) + n_k, (k = 1, 2, \cdots, 6) \quad , \qquad (1)$$

where $S(\lambda_i)$ is the spectral reflectance, $E(\lambda_i)$ is the spectral distribution of illumination, $R_k(\lambda_i)$ is the spectral sensitivities of the k-th sensor, and n_k is noise. Next, let $\boldsymbol{\rho}$ be a six-dimensional column vector representing all spectral camera outputs, **s** be a n-dimensional vector representing the spectral reflectance $S(\lambda_i)$ and **H** ($\equiv[h_{kj}]$) be an $6 \times n$ matrix with the element $h_{kj} = E(\lambda_i)R_k(\lambda_i)$. Then, the above imaging relationships are summarized in the matrix form $\boldsymbol{\rho} = \mathbf{Hs} + \mathbf{n}$. When the signal component **s** and the noise component **n** are uncorrelated, a solution that minimizes the estimation error on **s** is the Wiener estimator:

$$\hat{\mathbf{s}} = \mathbf{R_{SS}H^t}\left[\mathbf{HR_{SS}H^t} + \sigma^2\mathbf{I}\right]^{-1}\rho, \qquad (2)$$

where $\mathbf{R}_{ss}$ is an $n \times n$ matrix representing a correlation among surface spectral reflectances. We assume white noise with a correlation matrix $\sigma^2\mathbf{I}$.

The surface normal vector at each pixel of an oil painting surface is computed by using a photometric stereo method. If an object surface is a perfect diffuser, the light intensity I reflected from the surface illuminated by a light source is described as $I = \alpha\mathbf{N}^t\mathbf{l}_i$, where $\mathbf{l}_i$ is the illumination directional vector of i-th light source, and α is the diffuse reflectance factor. The surface normal vector **N** is estimated from above equation.

A reflection model is required to render realistic images of oil paintings. In our previous study (Nishi, Tanaka and Tominaga 2006), we found that the surface reflection of most oil paintings can be described by the Cook-Torrance model (Cook and Torrance 1981). The specular function of the Cook-Torrance model is fitted to the specular data extracted from all pixel points. Because the specular component at any pixel has the same spectrum as the light source, the parameters are estimated based on the statistical distribution of the specular component of the acquired images.

Image rendering is then performed based on all estimates of the surface reflection, which are the surface-normal vectors, the surface spectral reflectance, and the 3-D light reflection model parameters.

EXPERIMENTAL RESULTS

Figure 2 shows an oil painting used in the experiment. The painting surface was illuminated by a light source attached to measuring system at nine direction and measured from the vertical direction of the painting by the multiband camera attached to the measurement system. The multispectral camera connected with the PC and measured with remote control by gPhoto2. We

Figure 2: Oil painting of a natural scence.

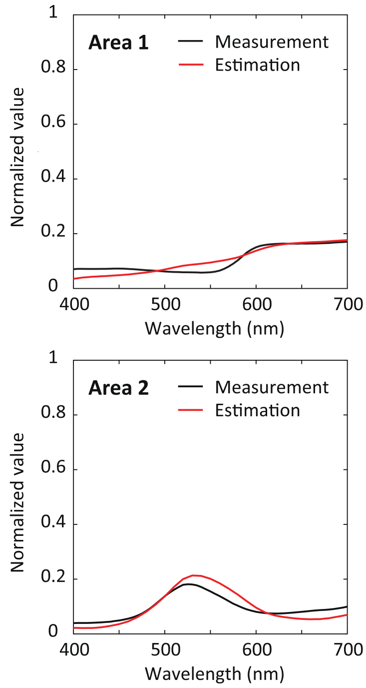

Figure 3: Estimated surface spectral

controlled the multispectral camera by executing script except for filter replacement. The operation executed in the script is shutter speed change operation and shutter release operation. Figure 3 shows the estimation results for the surface-spectral reflectance of Area 1 and Area 2 in figure 2, where the red curve and the black curve represent, respectively, the estimation with the present measuring system and direct measurement by using a spectrometer. The estimation results were obtained by the Wiener estimator in equation (2). It can be confirmed that the estimation accuracy of surface spectral reflectance is excellent in comparison with the measurement result.

Next, we estimated the surface normal vectors of oil painting. Figure 4 shows the shape image rendered by using the estimated surface normal. Although it is an evaluation based on the visual recognition of the painting surface, the shape estimation is performed with satisfactory accuracy. Finally, figure 5 shows the image rendering result using all the estimated surface properties and

Figure 4: Estimated surface shape of oil painting.

Figure 5: Image rendering result under D65.

the model parameters under D65. Compared with figure 2, it was confirmed that the rendered image was reproduced satisfactorily up to the details, such as the colour, surface shape and texture of the painting.

CONCLUSION

This paper has proposed a multispectral measurement system for estimating the detailed characteristics of an art painting surface. The proposed measurement system consisted of a multispectral camera and nine light sources, which were fixed to a device framed with a plastic-coated steel pipe and a joint. By fixing the camera and light source, the proposed measuring system could reduce the work space, improve work efficiency and work stability. Moreover, the number of contacts with the camera decreased dramatically by realizing remote camera control. We applied this multispectral measuring system for the digital archive of oil painting. We have described a method for digital archiving of oil paintings based the present multispectral measuring system. The availability of the present multispectral measuring system was shown by the experimental results.

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All the Colours of a Film: a study on the Chromatic Variation of Movies

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ABSTRACT

In this work, we discuss and present different techniques for film colour summarization together with a preliminary colorimetric study. The aim of this project is to combine the frames of different videos, reducing them to just one image of chromatic significance.

This elaboration is made through two different methods: the *movie barcodes* and *long exposure images*. Due to their nature, those concise images have not only an artistical aim, but are movies chromatic synthesis that can eventually be used for colour checks and for identification of dominances.

At first, we applied those methods on two videos from the Pixar Animation Studios' short animation movies. Then, as preliminary test, we present an application on the frames of a homemade video altered in different ways together with the relative visual and numerical results.

Keywords: *Colour movies, Colour histogram, Video Analysis, Image Analysis, Image Processing*

INTRODUCTION

Since its origin, cinema has tried to use colours to give movies a powerful and meaningful relevance [4,6]. In this work, we propose two different representations of entire movies in a single image.

At first, we show these methods applied to two videos from the *Pixar Animation Studios'* short animation movies, then we apply the same method on a short homemade video which colour has been altered in three different ways.

In the first method, the *movie barcodes* allow to follow the main chromatic content along the whole film, and the *long exposure image*s permit to create an impressionistic image as a kind of average colour spatial histogram.

A possible use of these methods, is to help in having a visual global idea of potential colour dominants.

STATE OF THE ART

Colour palettes and colour barcodes aren't a new idea: they can easily be found in literature and some of them can be downloaded from the web. Many of these generators, though, tend to just randomly pick colours or to reduce the whole frame into a one-pixel column averaging the pixels colours.

Two of the many websites that shares movie barcodes are: a Tumblr blog called *Moviebarcode* [7] and *The Colours of Motion* developed and created by Charlie Clark [2]. In Clark's work the movie is reduced in one image computing the average colour of an image and creating a line of pixels of this colour.

Different works were made by Martin Bellander [1] and Jason Salavon [5]. The first did something similar to a movie barcode but developing a code to analyse the use of colours in paintings over history, while Jason Salavon used a software of his own design to generate different types of images. Like Bellander, Salavon analysed paintings and created some sort of barcodes of MTv's music videos, but the most interesting work for us is his third project called *Amalgamation work*, in which he presents a synthesis and unification of pictures or movie frames. Salavon's *Amalgamations* remind of the photographer Jason Shulman's works, *Photographs of Films* in which photographs the entire movie using ultra-long exposures, obtaining a single image that captures the entire length of a film.

In 2013, Theodore Gray, the Co-founder of Wolfram Research [9], spent almost a year to develop an iPad app in partnership with Walt Disney Animated Studio. He and his team used the Mathematica software to create a feature they called *Colour Maps*, to extract the colour script out of a final animated movie. Theodore Gray's work was the one that inspired us to try and develop our own code to create different and representative images of movies, to produce a fast-visual colour analysis.

The selected short films

The movies from *Pixar Animation Studios'* are two: "La Luna" and "Presto". "La Luna" (2011) is directed and written by Enrico Casarosa. The short premiered on 6th June 2011 at the *Annecy International Animated Film Festival* in France, and it was paired with Pixar's *Brave* for its theatrical release on 22th June 2012, being shown before the film's beginning. The analysed frames are: 9840. The second selected short movie is "Presto" (2008), directed and written by Dough Sweetland. The short was release the 10th June 2008 at *Annecy Animation Film Festival* and it was paired with WALL-E the 27th June 2008. The analysed frames are: 7486.

For the second type of analysis we shoot a short video of Matera landscape and then we altered it in different ways. The video has been modified through the software *DaVinci Resolve* decreasing the values of one of the three channels. In this way we obtained three videos, one with just R and G channels, one with just G and B channels and one with just R and B channels. The analysed frames are 700 for each version.

MOVIE BARCODES

Here the steps for Movies Barcodes. The algorithm considers every single frame, divided in a R, G and B channels; the first step is the posterization of the image. In this part the algorithm computes the number of colours present in the image and then, this value is divided by a defined arbitrary

Figure 1 Workflow of the "Movie Barcode" algorithm.

number. For this experiment we selected a value of 100. So, for each RGB channel the values of colours (starting from 255) are divided by 100 and rounded to the lower value. This colour reduction permit to obtain a posterization of the image as is visible in FIG. 1. Then we rank the most used colour bins. Those operations are done for each frame and to plot the final images the algorithm built an image composed by a line of pixels of height 100 for each frame, in which the most frequent colour bins are reported in percentage.

With this method we obtained the images in FIG. 2 that show the 5 most present colour bins in each frame for both the analysed movies.

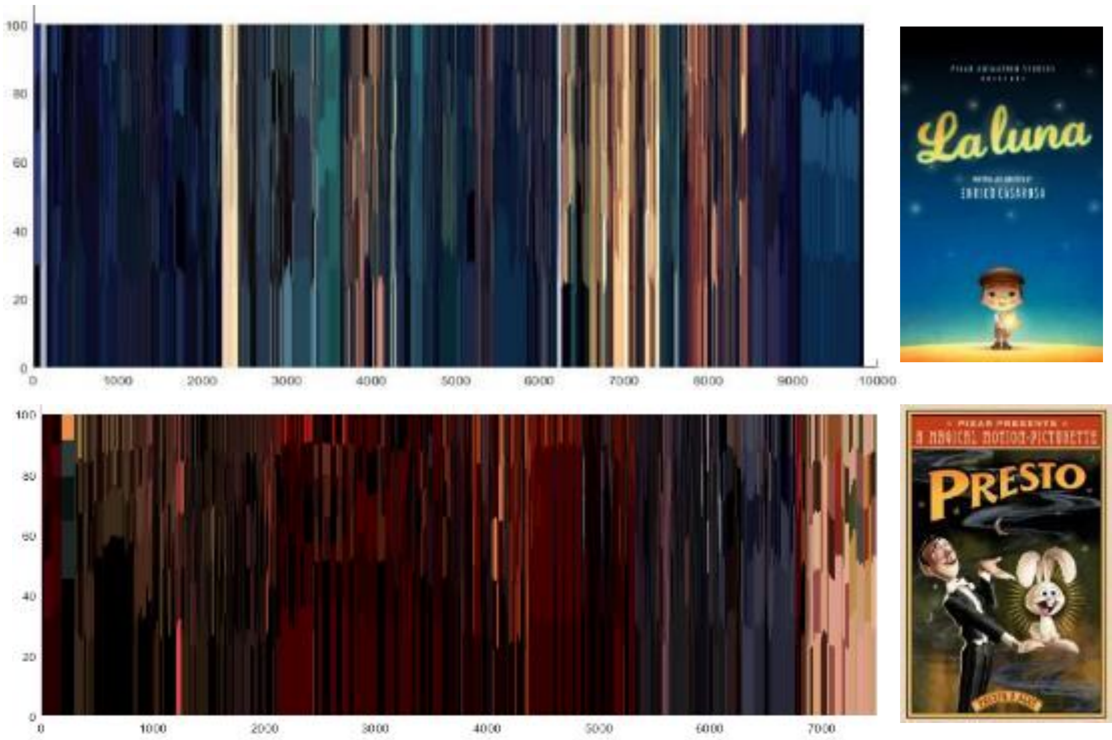

Figure 1 Movie Barcode palettes of "La Luna" (top) and "Presto" (bottom).

MOVIE LONG EXPOSURE IMAGES

For the realization of long exposure images, we created a simple code that sum and average all the frames of the movies.

The results of our movies long exposure images are visible in FIG.3.

Figure 1 Long exposure images of "La Luna" (left) and "Presto" (right).

RESULTS AND DISCUSSION

Figure 1 Same Frame of the modified video of Matera. The first is the original one, then we have the result of the reduction of each RGB channel.

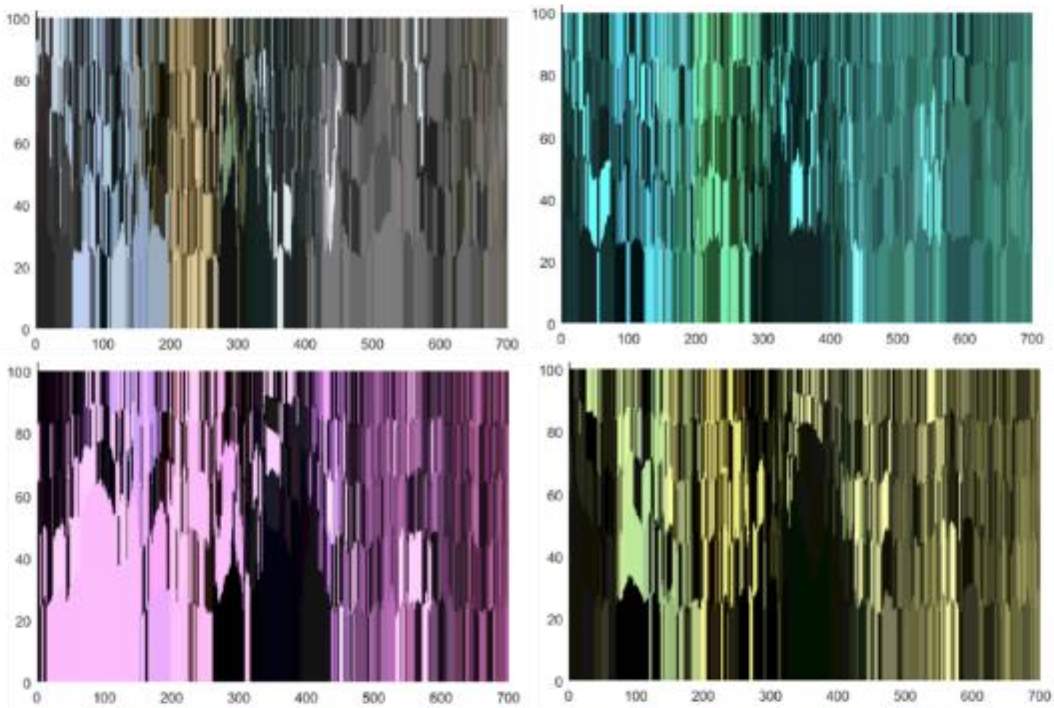

Figure 2 Movie Barcode Palettes of the original video of Matera (top, left) and the same video modified reducing one RGB channel.

FIG. 2 and 3 shown the two methods applied to the short movies "La Luna" and "Presto" and those syntheses provide information about the mood of the film and about the sequence of the different scenes. The first movie has a strong dominant of blue and light blue colours, that suggest calm and relax, despite the second that has a strong red dominance, that suggest action and movement.
Then, we applied the *Movie Barcode* method to a homemade video of the city of Matera and to 3 versions modified compressing each time a different RGB channel. A frame of the different videos is reported in FIG. 4.

In FIG. 5 we have a representation of the movie barcodes of the original video and of the altered ones. Here the different colour casts are visible.

	Mean			Difference from Original		
	R	G	B	ΔR	ΔG	ΔB
Original	170	171	170			
RG	163	165	147	-7	-6	-23
RB	188	167	187	18	-4	17
GB	149	182	177	-21	11	7

Table 1 The first chart indicates the RGB mean values of the movie Barcodes of the Matera's video. The second chart shows the value of RGB difference from the original video.

CONCLUSIONS

In this work we have presented two methods for the summarization of movie colours: *Movie Barcodes* and *Long Exposure Images*. With those methods is possible to visualize in a compress and alternative way the colours present in a movie.
We have presented these methods applied to short Pixar movies and *Movie Barcodes* to a homemade movie with altered colour, in order to test its capabilities of colour cast visualization.

ACKNOWLEDGEMENTS

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Colour Management in Virtual Reality applied to Lighting Simulations

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ABSTRACT

In this work, we studied the chromatic characterization of Head Mounted Displays (HMD) applied to Virtual Reality (VR) with the purpose of obtaining a better colour fidelity reproduction. We used two of the latest commercial version of HMD through Unity, a game development platform. It has been verified that no type of colour management is performed by default. We have defined in a 3D scene a uniform cube whose colour can be freely changed using RGB coordinates. We have made the chromatic characterization of both HMDs by measuring the spectral radiance of the HMD through its lens.

We have defined and programmed a colour management system applied just to light sources. Results show that it is possible to apply a chromatic characterization method to this type of display and it is also possible to define a colour management system to this type of virtual scene in real-time computing.

Keywords: *Colour Management, Lighting, Virtual Reality, Head-Mounted Displays, Colour Rendering*

INTRODUCTION

The measurement of the quality of light in both indoor and outdoor environments is a relevant topic that has gained attention due to its multiple applications. Recently, two colour rendering measurement recommendations have been approved; a) one sponsored by the Illuminating Engineering Society (IES, 2015) and b) another one subsidized by the International Commission on Illumination (CIE, 2017). These two standards allow us to measure the quality of light sources in terms of their colour reproduction properties. In addition to the concept of colour rendering, there are other important concepts related to the quality of a light source, such as the colour discrimination capability, colour rendering capacity, visual clarity, contrast perception, colour preference, or harmony. However, the effects of using an specific light source is difficult to simulate in terms of colour reproduction. There are few computer applications that allow spectral treatment of light sources and even less in real time. Recently, Virtual Reality (VR) has experienced a great development. Several commercial devices oriented to virtual reality have been developed by different companies such as Google, Oculus, and HTC. These Head Mounted Displays (HMD) allow visual immersive experiences in virtual environments.

In a previous work, the authors stated that the colour is the most significant factor influencing the quality of the virtual reality experience in terms of generation of the virtual image in relation to the original one (Pardo et al., 2018). In consequence, the improvement of the fidelity in the chromatic reproduction can be considered as a suitable further step towards the evolution of the quality of virtual reality systems.

The chromatic characterization of electronic devices is essential in order to accomplish the improvement of the chromatic reproduction of digital images; in this way, the univocal relation between digital and colorimetric values has to be known. This mathematical relation can vary depending on the type of device and has to be studied for each different type of technology (CRT (Berns, 1999), TFT (Pardo et al, 2004), OLED (Suero et al., 2010)). Once the mathematical relation between digital colour and colour independent from the device is known, a system for colour management has to be implemented and the colorimetric ICC profiles associated to each device have to be used.

The colour management system sets up a series of colorimetric transformations that allows to transform the coordinates of the colours spaces independent of the device (CIE XYZ, CIE Lab) to those of the colours spaces device-dependent (RGB, CMYK) and vice versa. All these mathematical transformations require a computation time that is often too long, since the device resolution and refresh frequency values are such that the colour management becomes inviable from the technical point of view, because the linking of several colorimetric transformations is needed.

Therefore, it is time to wonder whether it is possible to make a correct colour management in VR devices as it was done in other digital environments through the colour characterization of colour reproduction devices (Displays, printers, etc.) and the use of ICC colorimetric profiles. In this work, we face this issue in a first approach, propose a solution and show the results obtained.

EXPERIMENTAL

The difference between calibration and colorimetric characterization of a colour display device is always confusing. The calibration consists in setting its state to a known value. This can be done, for example, by fixing the white point, the gain, and the offset for a cathode ray tube. This guarantees the production of consistent results, and the calibration process can be completed without any information on the relationship between the device's input coordinates and the colorimetric coordinates of the output. The colorimetric characterization of the device, however, requires this relationship to be known: characterization consists in obtaining the relationship between the device's input coordinates and other device-independent coordinates. Due to the large number of chromatic stimulus that can be shown by any digital device, the direct measurement of this relation is impossible, and therefore a mathematical model is usually applied, allowing to reduce the number of runs.

We chose a display characterization model that does not require the actual operation of the display to be followed, but only seeks to relate as simply and accurately as possible the values of the DAC with the chromatic values of the stimulus in any reference colour space. In this work, we used the classical linear model implementing a previous non-linear gamma correction.

Prior to the chromatic characterization of both HMD, we tested the default colour management done by the 3D software platform used in this study, *Unity Game Engine*. Unity supports different rendering paths, and programmers can choose which one to use depending on the game content and the target platform: software and hardware. Different rendering paths have different performance characteristics that mostly affect visual appearance of the rendered scene. In particular, we defined a 3D scene in which we displayed an image with an embedded ICC profile which allowed us to easily check if the colour management had been is performed by the system.

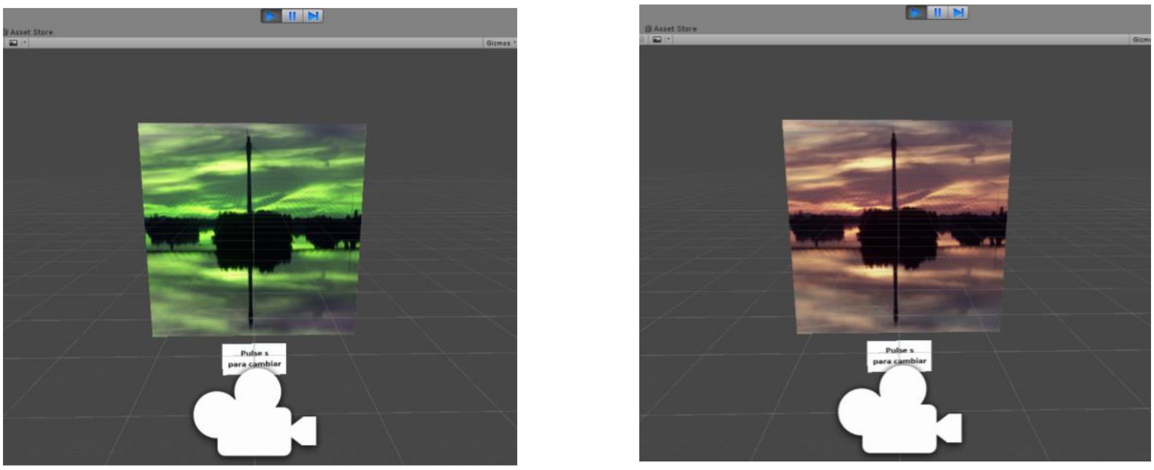

Figure 1: Screen capture of developed 3D scene without (left) / with (right) colour management.

This image altered the chromaticity coordinates of red and green channel in such a way that if the image is shown in red/orange tone, the system manages the colour in the correct way. On the other hand, if the appearance is greenish the colour management is wrong. In this case, it was verified that no type of colour management is performed by default (Figure 1, left). We implemented a colour management system that we can apply to the 3D scene to obtain a right colour reproduction of the image (Figure 1, right).

In the same 3D scene, we defined a uniform colour cube whose colour can be changed freely using RGB coordinates. We made the chromatic characterization of the HMD by changing the cube's colour and measuring the spectral radiance of the HMD through its lens. After the chromatic characterization of both HMD, we have defined their ICC colour profile files.

The measurement instrument employed was a Konica-Minolta CS-2000 tele-spectroradiometer with a spectral resolution of 1 nm between 380 and 780 nm, a <2% radiance measurement error and CIE 1931 x = ± 0.0015; y = ± 0.0010 colour error for an illuminant A simulator.

By means of a 3D model of a colour checker calibration chart (figure 3), scanned using a 3D scanner, we studied the effect of employing different real light sources (TL84, D50 simulator, A simulator) over the rendered scenes in Unity. We introduced the spectral power distributions (SPD) of all these light sources inside the chain of chromatic transformations done by our colour management system for Virtual Reality devices. Starting from the SPD, we have calculated the CIE 1931 XYZ tristimulus values of the light sources and the theoretical XYZ tristimulus values of each of 24 colour patches composing the colour checker. After this, we obtained the RGB, 24 bits per sample, digital values applying the ICC Colour Profile of each VR device.

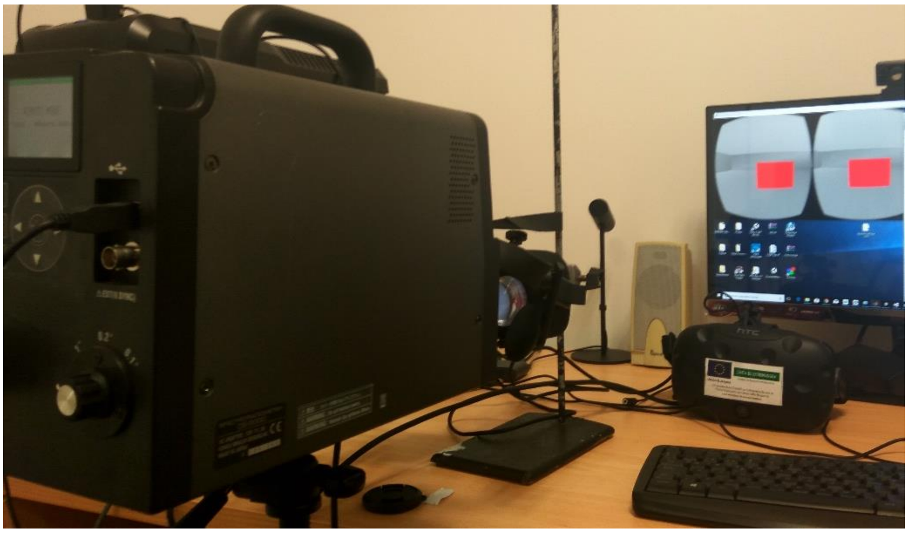

Figure 2: Experimental setup used for chromatic characterization of both HMD.

On the other hand, we captured the experimental RGB digital values of the colour checker using several virtual light sources inside Unity. Then, we calculated the XYZ tristimulus values applying the ICC Colour Profile in reverse way.

The main goal of these colour transformations is to compare the fidelity of colour reproduction at the virtual 3D scene illuminated with different light sources using a colour management system.

Figure 3: Virtual Light booth with colour checker calibration chart.

RESULTS AND DISCUSSION

Table 1 collects the colour differences between real and expected RGB and XYZ colour values, as obtained after the chromatic characterization of two virtual reality glasses and after capturing the digital images generated by Unity for each light source.

Light Source	$\overline{\Delta RGB}$			$\overline{\Delta XYZ}$			$\overline{\Delta E00}$
	R	G	B	X	Y	Z	
TL84	2.7	2.4	1.8	0.6	0.5	0.3	2.4
D50 Simulator	1.1	1.0	0.6	0.3	0.1	0.4	0.9
A Simulator	1.6	1.5	4.0	0.4	0.1	0.4	3.5
D50 Illuminant	0.6	0.4	0.3	0.3	0.2	0.2	0.5

Table 1: Average difference between theoretical and measured 24 bits RGB & CIE1931 XYZ values of 24 colour checker colours calculated for four light sources.

The results showed different average colour differences depending on the simulated light source. The greater the difference between the simulated light source and the light source used to generate the virtual image of the colour checker, the higher the colour average difference. It has to be taken into account that in this type of 3D scene design software there is a complex system of shadow calculation, secondary light reflexion, etc, that reduce the effectiveness of the digital colour managing systems.

CONCLUSION

Virtual Reality devices need a very high image refresh frequency and a very high screen resolution for a good immersive experience. These requirements make it difficult to apply a correct colour management to digital images. In this study, we made the chromatic characterization of this device and defined a colour transform library and an ICC colour profile. In this way, we have shown that it is possible to apply colour management transformations to colour images in VR devices and to obtain a better colour fidelity reproduction. A further step will be to apply spectral technics in lighting simulations.

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Lightness, chroma and hue distribution on Papilionidae butterflies

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ABSTRACT
In this study, we aimed to determine the distribution and combination of lightness, chroma and hue on butterflies from the Papilionidae family. We used hierarchical cluster analysis based on similarity retrieved from histogram intersection to classify images. Then, we analysed the results of colour distribution for each cluster from an image dataset, where the 118 images showed dominant low (high for some clusters) lightness with high contrast, dominant low chroma with different contrast, and dominant red–yellow (yellow–green to green for some clusters) hue with different contrast. Furthermore, when analysing the attribute combinations, we found contrast of lightness (i.e., similar chroma and hue), lightness and chroma (i.e., similar hue), or lightness and hue (i.e., similar chroma).

Keywords: *colour analysis, Papilionidae butterfly, hierarchical clustering, histogram intersection, CIELCh*

INTRODUCTION
Nature is full of colours, and humans are inspired by their beautiful combinations. In fact, we have been applying such combinations on a variety of materials and colour design methods (Kinoshita and Yoshioka, 2005; Design seeds, 2009; Hsiao and Tsai, 2015). Moreover, psychological studies suggest that colour combinations in nature are perceived as harmonious (Matsue, 1997; Adachi et al., 2008). Nevertheless, unveiling the colour combination system in nature is still an active endeavour. To quantitatively determine this system would improve colour understanding and design, as the laws of natural beauty could be revealed. Among creatures, humans are more attracted to colourful and winged insects (Gabriele et al., 2015), especially butterflies (Shipley and Bixler, 2017), which have evolved various colours patterns depending on the species (Beldade and Brakefield, 2002). In addition, butterflies have a high artistic value and are used as ornaments or

motifs on various artefacts (Matsuka, 1998; Watanabe, 2008). In this study, we focused on the Papilionidae family of butterflies that comprises many beautiful and large sized specimens (Layberry et al., 1998) to determine their colour combinations in terms of the distribution of lightness, chroma, and hue.

EXPERIMENTAL

To investigate several butterfly species in the Papilionidae family, an effective and efficient process is classifying them based on similarity of colour and analyzing the characteristics of each resulting cluster. Therefore, we used hierarchical cluster analysis based on similarities using histogram intersection (Swain and Ballard, 1991; Krishnamachari and Abdel, 1999) to classify images of different butterflies in the Papilionidae family. Our investigation on the colour attributes of the butterflies comprised four steps: 1) selection of butterfly images, 2) definition of variables for histogram intersection, 3) hierarchical cluster analysis, and 4) colour analysis.

We used 118 butterfly images for colour analysis considering that the species of butterflies appearing in books intended for general readership are usually preferred by humans. Specifically, we considered the 47 species of the Papilionidae appearing in more than two out of seven visual dictionaries and photo books intended for general readership (Preston and Otani, 2009; Unno, 2011; Imamori, 2014a; Imamori, 2014b; Hoskins, 2015; Hoskins, 2016). The 118 images corresponded to specimens of the 47 species and included colour polyphenism expressed as differences of patterns. The images were retrieved from the Integrated Digitized Biocollections (iDigBio Project, Gainesville, FL, USA). The iDigBio Project recommends a process for expressing images and photographs in the illuminants D65 or D50. Thus, we calibrated only images with colour distortions by adjusting white balance based on included colour standards in the images with Adobe Lightroom CC (Adobe Systems, Inc., San Jose, CA, USA). We edited the selected images using Adobe Photoshop CC 2017 (Adobe Systems, Inc., San Jose, CA, USA) with the nearest-neighbour interpolation tool as follows: We placed transparency pixels (A = 0) to remove background, insect pins, and loss parts of the wings and resized the width or height of the images to 400 pixels with a fixed ratio. We saved the images in the PNG format using the sRGB colour space.

Then, to investigate lightness, chroma, and hue distribution, we created histograms of each attribute using the CIELCh scale to define the variables for histogram intersection. First, we divided the H_{ab} values into 24 intervals and both the L^* and C^*_{ab} values into 20 intervals based on the colour order systems Munsell, Ostwald, and Practical Colour Coordinate System. We did not include the C^*_{ab} values under 10 into the H_{ab} histograms because hue with low chroma is almost imperceptible to humans. In addition, we created 200-interval histograms from the combination of the CIELCh attributes (i.e., 8 H_{ab} × 5 L^* × 5 C^*_{ab} intervals) based on the PCCS201-L specification. We truncated the C^*_{ab} values to 100 because they scarcely appear in the images, although the values range from 0 to 141. We normalized the frequencies of histogram and converted the sRGB colour space of the 118 images into the CIELCh scale. We calculated the similarity among every pair of images by applying histogram intersection on the four histograms corresponding to lightness, chroma, hue, and their combination.

We considered one minus the similarity as the distance among every pair of images and performed hierarchical cluster analysis using the Ward's method (Krishnamachari and Abdel, 1999) and distance matrices created from the similarities for the four histograms. We determined the number of clusters based on the sharp increase in height of the connecting points among clusters

Finally, we generated the graphs for colour analysis from the images in each cluster. Specifically, we created the histograms of each CIELCh attribute for the clusters containing similar images in lightness chroma, and hue. The intervals of these histograms were the same as above for H_{ab}, L^*, and C^*_{ab}. In addition, we generated four-dimensional scatterplots for the clusters. Likewise, the intervals of the scatterplots were 200 as mentioned above (i.e., 8 H_{ab} × 5 L^* × 5 C^*_{ab} intervals), with the fourth dimension represented as a bubble whose size represents the ratio of pixels per point.

We analysed the distribution of the L^*, C^*_{ab}, and H_{ab} histograms regarding the modal characteristics, peak distribution, colour difference among two adjacent peaks, and the dominance among peaks for all the histograms. In the four-dimensional scatterplots, we analyzed the range and dominance of the distribution concentrations.

RESULTS AND DISCUSSION

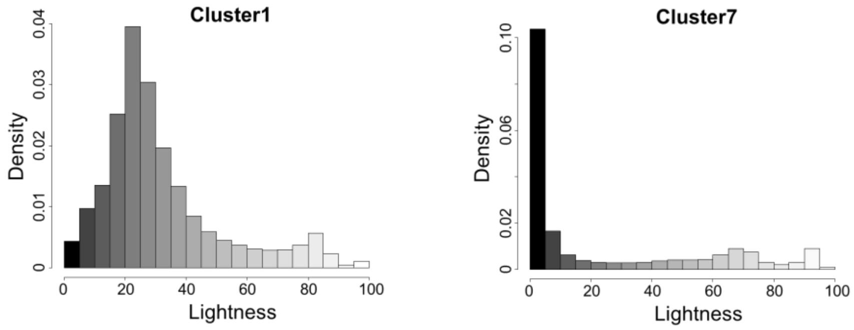

Figure 1: Lightness L^* histograms of clusters 1 and 7.

We employed 8, 8, 7, and 12 clusters according to the similarity in lightness, chroma, hue, and their combination, respectively. The distribution of L^* for clusters 1 and 7 is shown in Figure 1, where cluster 7 exhibits a single mode. In contrast, the other clusters showed bimodal histograms. For instance, in cluster 1, the two peaks are located at 20–25 and 80–85, with peak colour difference ΔL^* between 55 and 65, whereas the single peak of cluster 7 is located at 0–5. Overall, the peaks at lower lightness ($L^* < 50$) were dominant in clusters 1, 2, 4, 6, and 8, whereas those at higher lightness were dominant for clusters 3 and 5. In addition, the distribution of L^* in the bimodal histograms showed peaks ranging between 0 and 40 and between 75 and 90, with ΔL^* ranging between 45 and 90. These results suggest that the Papilionidae butterfly images used in this study have a dominant low lightness, with some specimens exhibiting high lightness, and general large colour differences (high contrast).

The distribution of C^*_{ab} for clusters 1 and 3 is shown in Figure 2. Clusters 3, 5 to 7 exhibited bimodal histograms, whereas the others exhibited unimodal histograms. For instance, the single peak in cluster 1 is located at 15–20, and the two peaks in cluster 3 are located at 5–10 and 85–90 with colour difference ΔC^*_{ab} among

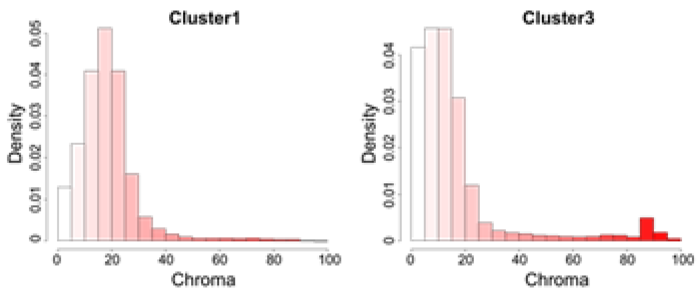

Figure 2: Chroma C^*_{ab} histograms of clusters 1 and 3.

them from 75 to 85. In clusters 3, 5 to 7, the peaks with lower chroma were dominant with values from 0 to 45, whereas the higher peaks showed values from 70 to 90 with colour difference ΔC^*_{ab} ranging between 20 and 85. Overall, the (dominant) peaks were located at low chroma values (C^*_{ab} < 50). These results suggest that the selected Papilionidae butterfly images for this study have dominant low chroma with variable colour differences (either high or low contrast).

The distribution of H_{ab} for clusters 1, 4, and 6 is shown in Figure 3, where cluster 4 has a bimodal, cluster 6 has a multimodal, and all the other clusters, such as cluster 1, showed unimodal histograms. The single peak in cluster 1 is located at 75–90°, the two peaks in cluster 4 are located at 30–45° and 90–105° with colour difference among peaks ΔH_{ab} of 45–75°, and the four peaks, p0 to p4, in cluster 6 are located at 30–45°, 120–135°, 180–195°, and 270–285°, respectively, with difference ΔH_{ab} of 75–105° between p1 and p2, 45–75° between p2 and p3, 75–105° between p3 and p4, and 105–135° between p4 and p1. The peak with acute angle in cluster 4 and obtuse angle in peak p2 of cluster 6 are dominant. Overall, most H_{ab} histograms were unimodal, with only one being bimodal and another being multimodal. The peaks were mainly located between 30 and 135°. The (dominant) peaks were located in the range 30–90°, which corresponds to colours from red to yellow depending on the categories proposed by Jonauskaite et al. (2016) and Blanchard and Haadsma (2002), except for clusters 5–7. The colour difference ΔH_{ab} ranged between 45 and 135°. These results suggest that the images used in this study have dominant red, orange, and yellow hue (yellow–green and green hue in some clusters) with variable colour differences (either high or low contrast).

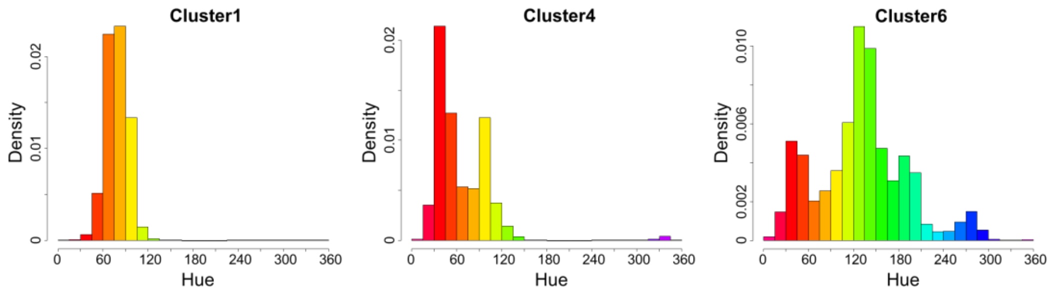

Figure 3: Hue H_{ab} histograms of clusters 1, 4, and 6.

Finally, Figure 4 shows the combination of all attributes in scatterplots for clusters 1 and 10. In clusters 1 to 5, 11, and 12, the dominant distributions ranges were 0–60, 0–40, and 0–135° for L^*, C^*_{ab}, and H_{ab}, respectively. Other ranges of L^* were 60–100, wider as 0–100, or narrower as 0–40. Ranges for C^*_{ab} included 60–80, 20–80, and 0–20. Ranges for H_{ab} included 90–135°, 0–90°, and 90–225°. These results suggest that the selected Papilionidae butterfly images for this study have a variety of colour combinations. For instance, dominant low

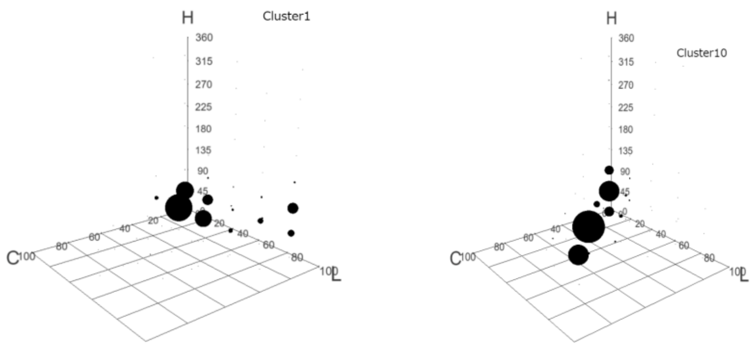

Figure 4: Four-dimensional scatterplots of clusters 1, 8, and 10. The vertical axis shows hue H_{ab} according to lightness L^* and chroma C^*_{ab}. The bubble size indicates the ratio of pixels per coordinate.

lightness and chroma and red–green hue produces colour combinations with high contrast only for lightness, for lightness and chroma, or for lightness and hue. Likewise, dominant high lightness and chroma and yellow–green hue produces colour combinations with high contrast for lightness and chroma. In contrast, dominant high lightness and low chroma and yellow–green hue produces colour combinations with high contrast only for lightness.

CONCLUSION

We determined the colour attributes of butterflies form the Papilionidae family by analyzing the lightness, chroma, hue, and their combination. We classified specimen images using hierarchical cluster analysis and similarities obtained from histogram intersection. The butterfly images in this study presented a dominant low lightness (high lightness for some clusters) and large colour difference for lightness. Likewise, we observed a dominant low chroma with variable colour difference, and a dominant red–yellow hue (yellow–green to green hue for some clusters) with variable colour difference. Furthermore, when analysing all the attributes, we found that specific combinations give rise to characteristic colour patterns, which vary among clusters of butterfly images. Overall, we determined that the 118 analysed images can have contrast in lightness, lightness and chroma, or lightness and hue. This study represents the first step to unveil the colour combination laws of the Papilionidae family of butterflies. Future studies will be focused on the analysis considering human perception by examining the differences between perceptual and automatic clustering.

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Natural Colors and Aesthetics in the Human Brain

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ABSTRACT

The colors of paintings and natural scenes are closely related but it is unclear what is the perceptual relationship of natural colors to aesthetics. One hypothesis is that aesthetic preference for colors is related to how natural the colors are perceived. We obtained individual scaling curves of naturalness and preference for natural images as a function of the angle of rotation of the color gamut. Naturalness and preference curves were found to be largely similar for the same images. In a fMRI experiment, the images were presented one by one in an event-related paradigm and the participants rated them for naturalness and preference. Whole-brain analyses revealed a modulation with naturalness in a prefrontal cortex region. These results suggest that aesthetic preference is closely related to how natural the colors are perceived. Furthermore, activity in certain brain areas correlates with the perception of naturalness.

Keywords: *paintings, aesthetics, fMRI, color vision, natural colors*

INTRODUCTION

The colors of paintings and natural scenes are closely related: several spatial and chromatic properties of paintings mimic natural scene statistics (Graham and Redies, 2010; Montagner et al., 2016). It is unclear, however, what is the perceptual relationship of natural colors to aesthetics. One hypothesis is that aesthetic preference for colors might be related to how natural the colors are perceived (Fernandez and Wilkins, 2008; Graham and Redies, 2010).

In experimental testing the degree of naturalness or beauty of an image can be manipulated by altering its spatial, colorimetric or cognitive content. For example, alteration of the spatial arrangement of abstract paintings does not seem to affect their aesthetic value (Gordon and Gardner, 1974; Vartanian and Goel, 2004). On the other hand, filtered images to produce out-of-focus representations considerably reduce beauty, both for abstract and representational paintings (Vartanian and Goel, 2004). Rotation of the color gamut of paintings also affects their appreciation (Nascimento et al., 2017).

We investigated the relationship between naturalness and preference by measuring preference and naturalness scaling curves for different rotations of the color gamut of natural images. Brain activity was also measured with functional Magnetic Resonance Imaging (fMRI) while participants rated the same natural images for naturalness and preference.

EXPERIMENTAL

Scaling curves for preference and naturalness for images of natural scenes were measured with a 2AFC scaling experiment (Kingdom and Prins, 2016) where the degree of naturalness and beauty was manipulated by rotating the color gamut of the images around the L* axis in CIELAB color space, thus preserving lightness and saturation but changing hue (Nascimento et al., 2017). In the naturalness condition, in each trial participants selected which image they perceived as more natural; in the preference condition, they selected which image they preferred for beauty.

Figure 1 shows one of the four images of the natural scenes tested. The images were synthesized from spectral imaging data (Foster et al., 2006; Linhares et al., 2008) and the radiance of each point was computed assuming the D65 illuminant. The images were presented on a calibrated display either in their original form, or spatially manipulated using a modified version of the 'Eidolon factory' (Koenderink et al., 2017) to remove their semantic content, but preserving their original color statistics (see Figure 1). In each trial they were displayed with their original color gamut or rotated rigidly in CIELAB color space by a variable angle, from -100 deg to 100 deg in steps of 20 deg. The display was a Display++ (Cambridge Research Systems, Rochester, Kent, UK) in Colour++ mode (14 bits per gun). Images were displayed with an average luminance of 12 cd/m^2. Twelve naïve participants were tested with 4 images.

In the fMRI experiment, two of the four images tested in the behavioral experiment were presented one by one in an event-related paradigm and the same participants rated them for naturalness and preference in different blocks. Nineteen naïve participants carried out the experiment with the two images in the behavioral and fMRI experiment. Structural and functional images were acquired using a Siemens 3T Prisma MRI system (Siemens, Erlangen, Germany) using a 64-channel head coil. During the first session, participant performed 2-4 blocks of the preference and naturalness task while brain activity was measured with a T2*-weighted 2D EPI sequence (Grappa acceleration factor = 2) with 38 axial slices covering the whole brain (FOV = 192x192 mm, voxel size = 3x3x3 mm, gap size = 255, TR/TE = 2100/30 ms). This was followed by a structural scan using a T1-weighted mprage sequence with 176 sagittal slices (FA = 8 deg, FOV = 256x256 mm, voxel size = 0.9x0.9x0.9 mm, TR/TE = 1880/3.53, phase encoding direction = row). During the second session, participants performed the remaining task block(s). Images were displayed on a Boldscreen (Cambridge Research Systems, Rochester, Kent, UK) in the same conditions as for the psychophysical experiment.

Functional images were corrected for head motion, aligned with the anatomical image and normalized to MNI space. For the first level GLM, we modeled the images under different rotations and spatial conditions using separate regressors. Head motion was included as nuisance regressors. At the second (group) level we contrasted activity for images at -100 and +100 deg versus their original.

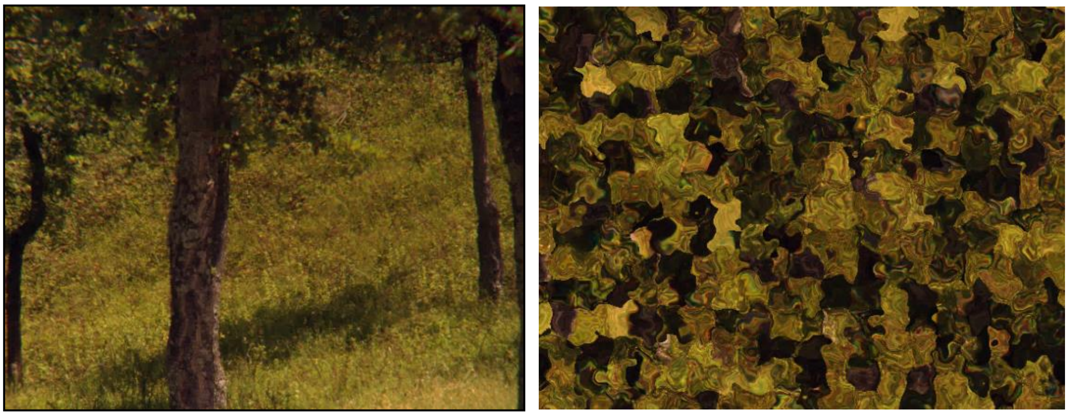

Figure 1. The stimuli were 4 images of natural scenes in their original form or spatially manipulated using a modified version of the ‘eidolon factory’ (Koenderink et al., 2017) to remove their semantic content, but preserving the original color statistics. Here we show one of the images and its manipulated version.

RESULTS AND DISCUSSION

Figure 2 shows scaling curves for one observer for the naturalness condition and for the preference condition. For all conditions of the experiment the maxima of the two types of curves were close to the gamut orientation of the original image, on average within 20 deg. Moreover, the naturalness and preference scaling curves were largely similar, with an overlap of the areas under the curves of 79% for the original images and 73% for the altered images. For scenes with vegetation the similarities were stronger than for scenes of urban images with artificial elements.

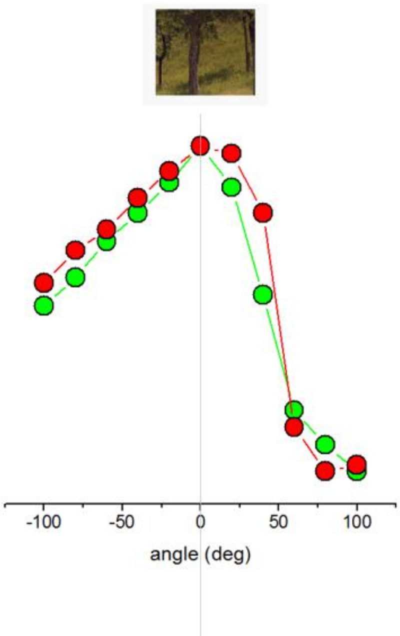

Figure 2. Example of scaling curves for one observer for the naturalness condition (green symbols) and for the preference condition (red symbols).

Whole-brain analysis of the fMRI data carried out by contrasting original images versus images rotated by -100 deg and by 100 deg revealed modulation by naturalness in a prefrontal cortex region ($p_{FWE\text{-}corr}$=0.049, p_{uncorr}=0.007, T 5.29, cluster extent = 70 voxels, peak voxel: -21 17 29). This region included (parts of) amongst others Caudate Nucleus, the Insula and the ACC, which are amongst others implicated in cognitive control, goal-directed behavior, saliency and working memory.

CONCLUSION3

These results suggest that aesthetic preference is closely related to how natural the colors are perceived. Furthermore, activity in certain brain areas correlates with the perception of naturalness.

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