



Can you imagine a world without colors? The physical and psychological effects of colors contribute to a satisfying and joyful way of life, far beyond aesthetic pleasure, in both natural and man-made environments. Color as an interface connects us with our surrounding environment, and color differentiates the things we need not only to survive, but to indulge in life and to appreciate it.

The aim of the conference is to explore how colors interact with our daily life, to approach the conscious and unconscious influence color may have on individual thought and perception, and how we can identify and apply colors from a healthier and more sustainable perspective. Seven fields of discussion have been selected for discussion: Color and Environment, Color Culture, Art and Design, Color Communication, Color Synesthesia and Visionary Projects, Color Science and Technology, Color Psychology, and Color Education.

"In Color We Live - Color and Environment" hopes to emphasize the importance of a colorful environment for a sustainable and healthy way of life, by addressing both individual and basic human needs, and by giving examples drawn from all aspects of life.

[www.aic2012.org](http://www.aic2012.org)  
[www.aic-colour.org](http://www.aic-colour.org)



Book of Abstracts

AIC 2012

In Color We Live: Color and Environment



*In Color We Live: Color and Environment*

# In Color We Live: Color and Environment

Interim Meeting of the  
International Colour Association (AIC)  
22-25 September 2012 Taipei, Taiwan

## Book of Abstracts

Editors: Tien- Rien LEE, James SHYU



**AIC** International Colour Association  
Internationale Vereinigung für die Farbe  
Association Internationale de la Couleur



9/21(Fri.)

CAT-AIC TAIPEI Special Jointed Conference (CCU Da-Xiao Arena)

09:30 Registration ♦

09:50 Opening

10:00 The Enigma of White  
Prof. Lindsay Macdonald ♦

10:40 Theory of Colour: History of Colour Systems  
Ms. Verena M. Schindler ♦

11:20 Let's color Hwa-Kang – adding color to our life  
Ms. Lotus Wu ♦

12:00 Lunch

AIC 2012 Workshop

13:00 NCS Colour Workshop  
Ms. Berit Bergstroem ♣

15:00 Break

15:15 RAL Colour Workshop  
Dr. Wolf D. Karl  
Prof. Axel Venn ♣

16:00 Break

16:15 Digital Archive for Museum  
17:00 Artwork Workshop  
Prof. M. James Shyu ♣

9/22(Sat.)

09:00-18:00 Executive Meeting ■

09:00-18:00 Pre-Conference  
Sight-Seeing Tour

18:00 EC Dinner (Yuan Shan Club) ☆

9/23(Sun.)

08:30 AIC 2012 Registration ♥

09:00 Opening Ceremony

09:40 Principles of color vision revealed by spatial complexity  
Prof. Steven Shevell ♥

10:20 Concert

10:40 Coffee Break

11:00 Color in traditional Chinese culture - Practical applications based on the Five Elements Theory  
Prof. Tien-Rein Lee ♥

11:40 National Park Presentation ♥

12:00 Group Photo

12:10 Lunch

<p><b>A1. Color and Environment</b> ♥ Session Chair: Mitsuo IKEDA (Tokyo Institute of Technology, Japan)</p>	<p><b>B. Color Culture, Art and Design</b> ♣ Session Chair: Nick HARKNESS (Pty Ltd., Australia)</p>
<p>13:20 The urban and rural environment - scaling outdoor scenes HUTCHINGS-et-al (UK)</p>	<p>From Charles Henry to Julio le Parc: Experimental research on colour, light and motion SCHINDLER (Switzerland)</p>
<p>13:40 Chromatic mutations in suburban areas NUYEN-et-al (Belgium)</p>	<p>Livecolour colourinhabiting in São Cristóvão, Portugal CONTE (Portugal)</p>
<p>14:00 SYN-TES: Interdisciplinary research on colour and light FRIDELL ANTER-et-al (Sweden)</p>	<p>The color expressions in the traditional costumes of the Taiwanese indigenous peoples TSENG-et-al (Taiwan)</p>
<p>14:20 Colour and light in the re-imagined birth environment BALABANOFF (Canada)</p>	<p>The language of color in textile design OBERLANDER (Argentina)</p>
<p>14:40</p>	<p>Colour in industrial design OBERASCHER (Austria)</p>
<p>15:00 Coffee Break</p>	
<p>15:20 Poster Session P1 ♥ Session Chair: Pei-Li SUN (National Taiwan University of Science and Technology, Taiwan)</p>	<p>Color Market ★</p>

17:00 Study Groups Meetings ■  
Colour Education (CE), Environmental Colour Design (ECD), Visual Illusions and Effects (VIE), Colour Perception of the Elderly (CPE), The Language of Colour (LC), 日本關西色彩學會

18:00 Welcome Reception ♥

9/24(Mon.)

09:20 Color and the Future – upcoming new color trends  
Prof. Axel Venn ♥

10:00 Coffee Break

<p><b>A2. Color and Environment</b> ♥ Session Chair: Maria Luisa MUSSO (University of Buenos Aires, Argentina)</p>	<p><b>C. Color Communication</b> ♣ Session Chair: Jinsook LEE (Chung Nam National University, Korea)</p>
<p>10:20 Color shift behind modern glazing ANGELO-et-al (Norway)</p>	<p>Color naming experiment using plural color stimuli under different viewing environments TANAKA-et-al (Japan)</p>
<p>10:40 Colorfulness and reflectivity in daylight spaces: Quantifying indoor color reflectance in terms of experience and performance HAGENLOCHER (USA)</p>	<p>What is a natural color? Natural colors and consumer expectations NIRINO (Argentina)</p>
<p>11:00 Wide area color signal estimation from reflected image on cornea surface OHTERA-et-al (Japan)</p>	<p>Interior colour design effects on preferred level of light HÄGGSTRÖM (Sweden)</p>
<p>11:20 The inconstant colour of green OLSSON (Sweden)</p>	<p>A new method to correlate music and colours HOEGG (Germany)</p>
<p>11:40 Always something else - Levels of experiencing colour and light KLARÉN-et-al (Sweden)</p>	
<p>12:00 Lunch</p>	
<p><b>A3. Color and Environment</b> ♥ Session Chair: Verena SCHINDLER (Zollikon and Atelier Cler Etudes Chromatiques, Paris)</p>	<p><b>D. Color Synesthesia and Visionary Projects</b> ♣ Session Chair: I-Ping CHEN (National Chiao Tung University, Taiwan)</p>
<p>13:20 Color in the Argentine Delta House MUSSO (Argentina)</p>	<p>Interaction of color and taste: Color synaesthesia in the food environment CAIVANO-et-al (Argentina)</p>
<p>13:40 Brightness evaluation for a room furnished with various chromatic objects YAMAGUCHI-et-al (Japan)</p>	<p>An fMRI Study on the perception of the harmony of color and fragrance SAITO-et-al (Japan)</p>
<p>14:00</p>	<p>As pink as an orange blossom odor: a Lebanese - French cross - cultural study MARIC-et-al (France)</p>
<p>14:20 Poster Session 16:00 P2 ♥ Session Chair: Pei-Li SUN (National Taiwan University of Science and Technology, Taiwan) (With Coffee Break)</p>	<p>Color Market ★</p>
<p>16:30 National Palace Museum Tour</p>	
<p>18:30 AIC 2012 Banquet (Taipei 101)</p>	
<p>22:00</p>	
<p>9/25(Tue.)</p>	
<p>09:20 Formosa –Taiwan's natural color expression Prof. Monica C. Kuo ♥</p>	
<p>10:00 Coffee Break</p>	
<p><b>E1. Color Psychology</b> ♥ Session Chair: Katsunori OKAJIMA (Yokohama National University, Japan)</p>	<p><b>F1. Color Science and Technology</b> ♣ Session Chair: M. Ronnier LUO (University of Leeds, UK)</p>

10:20 Prototyping experiences with food color  
QUIJANO-et-al (Colombia)

10:40 Effects of personal background on residential wall color preference  
BANIANI-et-al (Japan)

11:00 Contextual associations affect warm and cold colours  
DA POS-et-al (Italy)

11:20 Age effects on visual comfort as a function of lightness difference between text and background  
OU-et-al (Taiwan)

11:40 Color emotions of cubes and square patches  
KIM-et-al (Korea)

12:00 Lunch

<p><b>E2. Color Psychology</b> ♥ Session Chair: José CAIVANO (University of Buenos Aires and National Council for Research, Argentina)</p>	<p><b>F2. Color Science and Technology</b> ♣ Session Chair: Shoji TOMINAGA (Chiba University, Japan)</p>
<p>13:20 The Influence of Background on Colour Harmony MACDONALD (UK)</p>	<p>Spectral - based optimal daltonization model for dichromatic color vision KOTERA (Japan)</p>
<p>13:40 Readability of colored text on a colored background under led lighting and fluorescent lighting KUBO-et-al (Japan)</p>	<p>Early fungus infection detection in lemon fruits by means of spectral and colour analysis SANDOVAL-et-al (Argentina)</p>
<p>14:00 Psychological evaluation of the interior color scheme among ages YOKOI-et-al (Japan)</p>	<p>Intelligent spectral design for 3G and 4G light sources CHALMERS-et-al (New Zealand)</p>
<p>14:20 Prediction of a taste from color and its practical application PARK-et-al (Korea)</p>	<p>The modified uniform oil colour scale (MUOCS) MELGOSA-et-al (Spain)</p>
<p>14:40 Visual impression of a color group characterized by a colored light source and its applicability to color design ISHIDA-et-al (Japan)</p>	<p>A legibility study of the layouts and color combinations of e-Book titles SUN-et-al (Taiwan)</p>
<p>15:00 Coffee Break</p>	
<p><b>E3. Color Psychology</b> ♥ Session Chair: Osvaldo DA POS (University of Padua, Italy)</p>	<p><b>G. Color Education (Panel Discussion)</b> ♣ Session Chair: Javier ROMERO (University of Granada, Spain)</p>
<p>15:20 Effects of colour and chromatic light on depth perception ATLI-et-al (Turkey)</p>	<p>Session Chair: Javier ROMERO (University of Granada, Spain)</p>
<p>15:40 Color matching for colour constancy and inconstancy in the transition between foveal vision and extra-macular vision OLEARI-et-al (Italy)</p>	
<p>16:00 Demonstration of the color constancy in picture PHUANGSUWAN-et-al (Thailand/Japan)</p>	
<p>16:40 Closing Ceremony ♥</p>	
<p>18:00</p>	

♥ 8F Bo-Ying Center ♦ 3F Jian-Yi Lecture Hall  
■ 9F ♣ 803 ★ 805 ♣ 903 ☆ Grand Hotel



# **AIC 2012 Interim Meeting of the International Colour Association (AIC)**

In Color We Live: Color and Environment

**Book of Abstracts**





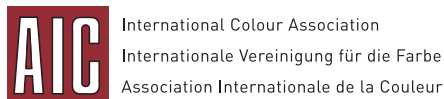


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## **BOOK OF ABSTRACTS**

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# AIC President's Message

It is with great pleasure that AIC is coming to Taipei, especially since it is the first time that Color Association of Taiwan is holding an AIC Meeting. It was three years ago we got your application to become a regular member and you have been a member since the end of 2009. Almost immediately after joining AIC, Color Association of Taiwan enthusiastically invited AIC to their country for a meeting in 2012. So this is really an occasion for celebrating.

This is the 39th AIC meeting since the first meeting was held, 43 years ago, in Stockholm. We can see an increased interest in the AIC meetings the last years and the number of delegates at this meeting is round 250! At this meeting we are also very proud to announce the winner of the AIC Logo Competition for the International Colour Day March 21st. We hope that all of you will have color activities in your country all over the world in the same colorful day.

Now we are looking forward to three coming days of this AIC meeting with the theme, "In Color We Live: Color and Environment" and it is about understanding the effects of colors in natural and man-made environments which contributes to create healthier living spheres through color applications. In this theme we will listen to the importance of color and commonly raised questions like: What effect does the color of a room have on the people in it? How are we affected by colors? Few things influence us as much as color and few things engage and interest people as much as color. Color plays an essential role in our environment.

I would like to thank especially Professor Tien-Rien Lee, the chair of Color Association of Taiwan and his team and the Chinese Culture University for the great organization of this meeting. I also would like to thank the members of the international scientific committee who reviewed 244 abstracts which has resulted in 45 oral presentations and 115 poster presentations..

After the very successful and memorable meeting in Zürich, Switzerland we are now working on the coming meetings. Next year's meeting will be the 12th AIC Congress which will take place in Newcastle, Great Britain, July 8-12. AIC Interim Meeting 2014 "Colors, Culture and Identity: Past, Present and Future" will be in Oaxaca, Mexico, October 29 – November 1. The AIC Midterm Meeting 2015 "Color and Image" will be in Tokyo, Japan in May. 2016 is still open. The 13th AIC Congress will be held in Jeju, Korea October 16-20, 2017.

I am sure that the members of the organizing committee have done their best to ensure that this meeting will work out under the best possible conditions, that the proceedings will be interesting and that it will be exciting to learn about the latest developments under the theme of , "In Color We Live: Color and Environment". I am sure there will be many memorable moments and fruitful meetings to remember in the coming years. In Taiwan - the beautiful island with towering mountains and beautiful coastal scenes.



A handwritten signature in black ink, which appears to read "Berit Bergström". The signature is fluid and cursive, with a long horizontal line extending to the right.

Berit Bergström, AIC President  
Stockholm, August 2012

# AIC, International Colour Association

## AIC Executive Committee

<b>President</b>	Berit Bergstrom
<b>Vice-President</b>	Prof. Dr. Javier Romero
<b>Secretary/Treasurer</b>	Nick Harkness
<b>Committee Members</b>	Prof. Lindsay MacDonald Shoji Tominaga Verena M. Schindler Maria Luisa Musso

## Member Countries

<b>Argentina</b>	Grupo Argentino del Color
<b>Australia</b>	Colour Society of Australia
<b>Brazil</b>	Associação Pró-Cor do Brasil
<b>Bulgaria</b>	Colour Group – Bulgaria
<b>Chile</b>	Asociación Chilena del Color
<b>China</b>	Color Association of China
<b>Finland</b>	Suomen Väriyhdistys Svy Ry
<b>France</b>	Centre Français de la Couleur
<b>Germany</b>	Deutscher Verband Farbe
<b>United Kingdom</b>	The Colour Group [Great Britain]
<b>Hungary</b>	Hungarian National Colour Committee
<b>Japan</b>	Color Science Association of Japan
<b>Korea</b>	Korean Society of Color Studies
<b>Mexico</b>	Asociación Mexicana de Investigadores del Color
<b>Netherlands</b>	Nederlandse Vereniging voor Kleurenstudie
<b>Poland</b>	Lówny Urząd Miar
<b>Portugal</b>	Associação Portuguesa da Cor
<b>Slovenia</b>	Drustvo Koloristov Slovenije
<b>South Africa</b>	Colour Group of South Africa
<b>Spain</b>	Comité Español del Color
<b>Sweden</b>	Stiftelsen Svenskt Färgcentrum
<b>Switzerland</b>	Pro/Colore
<b>Taiwan</b>	Color Association of Taiwan
<b>Thailand</b>	The Color Group of Thailand
<b>United States</b>	Inter-Society Color Council

## Associate Members

International Association of Color Consultants/ Designers, North America [IACC-NA]  
Gruppo del Colore , Italy

## AIC Study Groups

<b>Color Education (CE)</b>	Dr. Robert Hirschler, Chair
<b>Environmental Color Design (ECD)</b>	Verena M. Schindler, Chair
<b>Visual Illusions and Effects (VIE)</b>	Prof. Dr. Osvaldo da Pos, Chair
<b>Color Perception of the Elderly (CPE)</b>	Dr. Katsunori Okajima, Chair
<b>The Language of Color (LC)</b>	Prof. Dr. Jin-Sook Lee, Chair



[www.aic-colour.org](http://www.aic-colour.org)



# AIC 2012 Chair's Preface

Since the official hand-over of the AIC banner from the Swiss color organization pro/colore to the CAT delegation of Taiwan in Zurich 2011, an ambitious program under the conference theme 'In Color We Live – Color and Environment' has been created with a total of 244 abstracts submitted. The final program lists four keynote lectures, 45 oral papers, and 115 posters to be presented to an expected audience of more than 200 international color experts from 27 countries, offering participants the opportunity to discuss latest color trends and developments during the three conference days from Sep. 23-25, 2012. We have included many additional highlights for you like a Chinese music concert, dance performance, and a top-level banquet in one of the world's highest restaurants in the Taipei 101 tower.

I would like to thank the members of the AIC 2012 International Scientific Committee for reviewing the submissions: their professional commitment has been an indispensable contribution to the efforts of the AIC 2012 Organizing Committee, and helped shaping the program to become the solid foundation for the whole exciting conference.

The AIC 2012 venue is at Chinese Culture University, including a color market on site. The conference is going to be broadcasted by internet live streaming; and social media are used for delivering the message of the event to an even broader international audience via cell phone apps and a facebook presence, as well as by a range of colorful souvenirs. Besides, AIC 2012 offers pre-conference excursions to four different destinations around Taipei and along the north coast, covering visits to the Taipei Museum of Modern Arts and the National Palace Museum, and two after-conference trips to Yang-Ming-Shan and to Taroko Gorge National Park near the east coast city of Hua-lien.

I would like to extend my deep thankfulness to our sponsors, all experts and participants for their valuable contribution and commitment, which has made possible the AIC 2012 Interim Meeting to become a fascinating color event. We hope you will enjoy the warm hospitality of the people in Taiwan, the natural heritage and cultural peculiarities of this beautiful land - Formosa.

We are very grateful to have the chance of receiving you, and hope you will indulge in exploring our colorful world as much as possible!

I wish you all a most inspiring conference, and a most joyful stay in Taiwan!



*Tien-Rein Lee*

Prof. Dr. Tien-Rein LEE  
AIC 2012 General Conference Chair

# *In Color We Live: Color and Environment*

## *Conference Topics*

Under the theme “In Color We Live: Color and Environment” AIC 2012, Taipei, provides a platform for experts from the research, business, and artistic color industries. The conference invites to engage in future-oriented exchange and to build and intensify networks in different fields of interest from both theoretical and practical points of view. By investigating terms and concepts related to color as an interface of perception, nature, and man-made environments, the AIC 2012 Interim Meeting offers to explore color in its individual perception, interior and exterior contexts, by different terminologies and methodologies, and last not least, in its applications for industrial and everyday products.

The AIC 2012 Interim Meeting aims to inspire and encourage the scientific dialogue, and to meet the challenges of future color research and development, by emphasizing the importance of the environment and our daily interactions with color.

## **Conference Topics and Sub-Topics**

Submissions were accepted for consideration in any of the topics mentioned below.

### **A. Color and Environment:**

Nature, lighting, interior architecture, exterior architecture, landscaping & horticulture, urban design & planning.

### **B. Color Culture, Art and Design:**

Aesthetics, history, philosophy, transportation, food, medical & personal care, warning systems, fashion design, performance, painting, sculpture and installations, ceramics & glass, jewellery and metalwork, art conservation.

### **C. Color Communication:**

Interpretations, color codes & symbols, semiotics, visual communication & design, color naming & language, color categorization, color order systems.

### **D. Color Synesthesia and Visionary Projects**

visual models, color physics, color chemistry, image reproduction, color management system, high dynamic range imaging, multispectral imaging, computational photography, multimedia in color imaging, 3D color imaging, virtual reality (VR) and augmented reality (AR), display and printing, colorimetry, industry applications.

### **E. Color Psychology:**

color perception, color preference, physiology & psychophysics, light & color interaction, color vision and aging, vision illusions and effects, defective color vision.

### **F. Color Science and Technology:**

Visual models, color physics & color chemistry, image reproduction, color management system, high dynamic range imaging, multispectral imaging, computational photography, multimedia in color imaging, 3D color imaging, virtual reality (VR) and augmented reality (AR), display and printing, colorimetry, industry applications.

### **G. Color Education:**

Pedagogy, terminology, methodology, electronic media applications, teaching aids.

# AIC 2012 in Taipei – Welcome to our Colorful World

The conference topic “In Color We Live – Color and Environment” is represented by the many natural and cultural symbols of Taipei and Taiwan, embedded in the world of colors like the island is situated between the Eurasian Continent and the Pacific Ocean:

Earth is placed between the water and a multitude of colorful shapes flourishing like plants and towering like mountains, resembling the abundance of nature, which is much greater than all shapes that can be created by humans.

A closer look at the picture reveals the skyline of the venue of AIC 2012, Chinese Culture University, and the Grand Hotel nearby. Rising up high into the sky, bamboo-shaped Taipei 101 Tower reaches out like modern society for the future to come.

Taiwan’s opulent fauna and flora is indicated by its endemic species like the Formosan white-throated black bear, the Formosan landlocked salmon, the Taiwan Magpie (or Formosan Blue Magpie), and the Formosan Sika deer. Besides, the Taipei Tree Frog and butterflies stand for the peculiarities of Taipei and Taiwan: with 377 recorded species, of which 56 species are reportedly endemic to the island, Taiwan is well-known as the world’s kingdom of butterflies. A species of the Orchidaceae family is the Taiwan Pleione. Commonly beloved flowers are the Azalea and the Mexican Aster.

We warmly welcome to enjoy our colorful world: Welcome to Taipei!

## The AIC 2012 Logo

The logo is composed of primary colors of the Component Theory, and neutral colors. Green and blue also stand for mountains and the sea, yellow for the sunrise and red for the sunset—natural colors of the environment. The shape resembles a hand-shake and a smiling face. It also stands for the Tai Chi symbol, rotating actively and continuously generating life energy (“Chi”). Its irregular shape is both harmonically balanced and endlessly moving.

The logo stands for the connected world we live in: through a constant flow of exchange, life comes into being, following the natural energies of creation and decay, represented by the two basic principles of the cosmic Tao - Yin and Yang in a colorful way.

“In Color We Live” stands for the colorful meanings of our lives – for our personal color preferences as well as for our daily living environment, the man-made as well as natural surroundings. The five colors of the Chinese Five-Elements-Theory – green-blue, red, yellow, white and black – accompany and guide us through the changes of day and night and the seasons for our entire lifespan long.

When East meets West we recognize each other by the similarities and differences that make everyone so special. Hands are shaken in a gesture of friendship and mutual collaboration, for the future research and well-being, and the prospering of color studies around the world.



## **Chinese Culture University (CCU)**

Chinese Culture University (CCU) is one of the most reputable and the largest private universities in the Republic of China. Surrounded by the beautiful mountain nature resort of Yang-Ming-Shan and with a magnificent view over Taipei city, the main campus provides its students, faculty, and visitors with a peaceful and convenient environment for research and academic growth. CCU has a branch campus in Taipei city. Its School of Continuing Education (SCE), is the largest and the most successful in Taiwan, with branches throughout the island. Formerly known as Far-Eastern University, CCU is a private, comprehensive university fully accredited by the Ministry of Education of the Republic of China (ROC) since 1962. It was founded by Dr. Chang Chi-Yun, the former Minister of Education of ROC, and named by the late ROC President, Chiang, Kai-shek. Over five decades, CCU has grown to become one of the best and the largest universities in Taiwan, with more than 80 sister universities worldwide. Since its establishment, CCU carries the mission of preserving the essence of Chinese culture, language, philosophy, and values. Also, CCU places special emphasis on international learning, international exchanges, and foreign languages to prepare students for the increasing demands, challenges, and competition of the international market, ensuring their success in the era of globalization. CCU presently consists of 12 Colleges, with 59 undergraduate departments, 40 master and 11 doctorate institutes. SCE has 10 departments and 11 graduate institutes, offering various courses, professional trainings, and degree programs for students of all ages.

### **Hsiao Feng Library**

The university's library - Hsiao Feng Library - was built in memory of the CCU founder, Dr. Chang Chi-Yun, alias Mr. Hsiao-Feng, and opened on March 1, 1999 in celebration of the university's 37th Anniversary. It is one of the best libraries in Taiwan, storing more than one million books, a rich collection of periodicals, video, tapes, CDs and special archives. It runs an automated electronic service system, and includes an exhibition area, study rooms, and a multi-media service center.

### **Hwa Kang Museum**

Established in 1971, the University Museum (Hwa Kang Museum) was the first comprehensive museum of its kind in Taiwan. Its permanent collection covers Chinese ceramics made during different historical periods, more than 4,000 master pieces of Chinese calligraphic works and paintings, and a great variety of Chinese folk artifacts and woodblock prints. It maintains the Ou Hao-Nian Art Center, and a special room for displaying precious CCU historical documents and archives. The museum encourages artists in the neighboring community to interact with art works exhibitions.

### **Da-Xiao Arena**

The newly completed CCU gymnasium is one of the most outstanding in Asia: The 14-floor building offers state-of-the-art facilities for all kinds of physical education including golf, baseball trainings, billiards, dance studio, table tennis, athletic recovery rooms, gymnastic training room, Taekwondo practice room, a swimming pool and Spas for men and for women. The building includes an administrative part and rooms for official events.



# Color Association of Taiwan (CAT)

## 中華色彩學會

The National Taiwan Color Association was founded in 2001, and officially named "Color Association of Taiwan (CAT)" on 21 July 2001, during its annual General Assembly. Among the founders of CAT were the color research experts Tien-Rein Lee, Lu-Yin Juan, Shin-Chuan Yao, Ming-Ching Shyu, Chun-Yen Chen, Lin-Lin Chen, Wen-Guey Kuo, Chung-Yi Chang, Shing Sheng Guan, Tsao-hung Wei, and others.

The Color Association of Taiwan (CAT) aims to:

1. integrate color-related knowledge in Taiwan in order to cultivate the expertise and understanding of color in the fields of science and arts.
2. form study groups to explore new territories of color studies and applications to enrich color utilization and education.
3. link with the international color communities, to develop advanced collaborations and cross-cultural research.

CAT's activities cover a broad range of color-related fields, both industrial and academic, with a strong foothold in business. Since 2010, CAT has become a member of the International Color Association (AIC). This is a big milestone in the Association's history, marking its entry to the international stage. CAT has become one of the most active members, with our delegations attending the worldwide AIC conferences every year. We are very grateful for this opportunity to build up more intense networking and collaboration on an international scale.

In responding to the rapid changes of the Age of the Digital Sciences, CAT offers some of the few platforms promoting color science and related arts in Taiwan to become a more and more differentiated field of study; ranging from fine arts, design, ecology, architecture, optics, and printing up to psychology and more. To date, 12 congresses have taken place, introducing color research to a broader audience, and facilitating exchange between

international color experts. CAT conducts its General Assembly and the International Scientific Color Symposium on Color Design and Application on an annual basis, including lectures and discussion forums, and publishing the Symposium proceedings. Besides, irregular meetings and workshops on special topics are organized with invited international color experts. Furthermore, CAT is involved in promoting color knowledge together with other Asian color organizations, forming a strong-tied Asian Color network, and strives to actively expand cooperation with global partners.

In 2012, CAT holds its 13th congress together with the AIC 2012 Interim Meeting in Taipei. We highly welcome this wonderful opportunity to make friends with many more color experts from all over the world! By shaping this international conference into a multifaceted platform, we hope and encourage the color research communities, artists and industries to engage in a most intense and fruitful exchange, and to inspire color studies through globalization, interdisciplinary collaboration, and the spirit of innovation.

In this Age of the Digital Sciences, CAT strives to evoke the attention from various fields of research, business and arts, to realize the importance of colors, and to collaborate for a better understanding of our commonly shared, colorful world.





# AIC 2012 Committees

## AIC 2012 Organizing Committee

<b>Conference Chair</b>	Tien-Rien Lee
<b>Technical Chair</b>	James Shyu
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<b>Ming Ronnier Luo</b>	<i>UK</i>		



# Keynote lectures, Oral papers

in order of presentation



**Prof. Steven SHEVELL**

Steven Shevell is the E. H. Moore Distinguished Service Professor at the University of Chicago, in Psychology, Ophthalmology & Visual Science, and Computational Neuroscience. He received an undergraduate degree in psychology and an M.S. in engineering from Stanford University; and an M.A. in statistics and Ph.D. in mathematical psychology from the University of Michigan. He was the founding associate editor of the *Journal of Vision*, a former senior editor of *Vision Research*, and the editor of the *Optical Society of America's* most recent edition of *The Science of Color*. He is a past-president of the Vision Sciences Society, and currently serves on the board of directors of the International Colour Vision Society.

***Principles of color vision revealed by spatial complexity***

Prof. Steven K. SHEVELL

Psychology and Ophthalmology & Visual Science, Institute for Mind and Biology,  
University of Chicago

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***Abstract***

Chromatic background fields reveal fundamental aspects of color vision. Increment-detection thresholds as well as color appearance vary systematically with the wavelength of a uniform background. Quantitative modeling of these shifts has advanced color theory for more than a century. Uniform backgrounds, however, are rare in the natural world where, instead, the background typically is a mosaic of many different chromatic lights in view simultaneously. Recent studies show that chromatic variation within a background – spatial complexity – unveils basic neural processes of color vision that cannot be detected with a uniform background.

The spatial complexity of a background is an elementary property of a scene but often overlooked. The minimum number of different background colors required for spatial complexity is two, and experiments show that two different chromaticities within a patterned chromatic background are sufficient to cause large shifts in color appearance. Importantly, these shifts are larger than those caused by a uniform background at either of the two chromaticities presented alone. Furthermore, the spatial frequency of the patterned chromatic background is a critical determinant of the background's effect on color, revealing a neural mechanism that depends on center-surround receptive-field organization. In addition, interocular transfer – that is, the color shift in a light presented to one eye caused by a spatially complex background seen by only the other eye – reveals that the color changes from spatial complexity are mediated by a cortical neural mechanism. A cortical mechanism is consistent also with the highly selective loss of chromatic sensitivity caused by a spatially complex background composed of colors restricted to a particular direction in color space (Webster et al, *Journal of Vision*, 2002). Finally, chromatic spatial complexity also reveals that perception of three-dimensional shape can affect color appearance and, reciprocally, chromatic patterns within a scene can alter perceived three-dimensional shape. In sum, chromatic spatial complexity is a critical feature of a scene that contributes to both color perception and to the influence of chromatic neural signals on percepts other than color.



## **Prof. Tien-Rein LEE**

Prof. Dr. Tien-Rein Lee was President of the Chinese Culture University (CCU) from 2003-2009. He was Chairman of the Department of Graphic Communications, Dean of the College of Journalism Communications, Dean of the Center for Information and Communications, and Dean of General Affairs at CCU. Prof. Dr. Lee is now teaching Visual Communication, Color Communication and Communication Technology at the Department of Information Communications of Chinese Culture University. One focus of his current research interest is color application in Chinese culture. Prof. Dr. Lee is now President of the Color Association of Taiwan (CAT), President of the Chinese Culture University's Alumni Association, and President of the Chinese Association for Life-long Learning (CALL).



### ***Color in traditional Chinese culture - Practical applications based on the Five Elements Theory***

Tien-Rein LEE

President, Color Association of Taiwan

Professor, Dept. of Information Communications, Chinese Culture University

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#### ***Abstract***

Color has played an important role in Chinese culture since its early beginnings, as can be traced by the Theory of the Five Elements (also called phases, essences or stages). This early and very influential doctrine of ancient China is deeply rooted in Chinese culture, based on the concept of the harmonious relations and interactions of the three spheres of heaven, earth and humans, and merging the wisdom and life experience of former generations with traditional color application in daily life.

The color concept builds on five basic colors, each one being associated with one of the five elements identified by Chinese philosophy: blue/green-wood, red-fire, yellow-earth, white-metal, and black-water. Every element connotes to certain life qualities and natural phenomena, such as the directions, the seasons, life factors and many more: wood-east, spring, birth; fire-south, summer, growth; earth-central, late summer, ripening; metal-west, fall, decay; and water-north, winter, death. By closely watching their environment, people associated natural phenomena and their colors with potential influences on their daily lives. Besides, the identified five elements were thought of as an interconnected and interdependent system driven by a core mechanism of mutual exchange explained as "the constructive and the destructive rules", determining the way of how people were to choose colors of favorable effects on their daily life. The Theory of the Five Elements and color representing the natural life forces became an indispensable part of a natural and dynamic concept that served for people's survival and constant improvement of their life standards, even becoming influential on a person's fate, similar to fortune-telling. This article introduces how the Chinese people used colors since ancient times. It explores how much color application based on the doctrine of the Five Elements is still alive, by presenting examples of practical use. Following an explanation of the underlying philosophical thought and key terms, Chinese daily color use is shown by selected fields of applications like nutrition, medicine, architecture, design, administration, and military. It is perfectly worth discussing if methods of modern sciences can prove this dynamic color theory, to re-assess the preserved insights, and maybe discover beneficial knowledge and rules for people's lives which might help to make our lives more comfortable and happier.

9/23 Sunday  
11:00 - 11:40



## Prof. Axel VENN

Axel Venn studied at the famous Folkwangschule für Gestaltung in Essen, Germany, Design and Arts. Since 1983 Axel Venn has his own studio. He works all over Europe and partly world wide as a design strategy- and colour-consultant and research scientist. He works among design innovations for RAL, ICI, Beiersdorf, Du Pont, Dunlop, Lambert, Siemens, WMF, St. Gobain, GlaxoSmithKline, Hornbach, Brillux etc. and some international fairs. He is Kurator of the Deutsches Farbenzentrum e.V., Berlin, and member of the trend panel of Mood, Bruxelles, and other trend circles. He is Professor em. for Colour-Design and Trendscouting at the University of Applied Sciences and Arts, HAWK, Hildesheim, Germany. Axel Venn is well-known for the seminars and lectures, in NewYork, Atlanta, London, Vienna, Cologne, Bruxelles, Paris, Moscow, Prague, Beijing, Shanghai, Nice, Colorado Springs, Taipei etc. He published hundreds of articles and more than sixteen books, translated in twelve languages, about colour-science, design, trend and marketing. He lives and works in the city of Berlin.



### ***Color and the Future – upcoming new color trends***

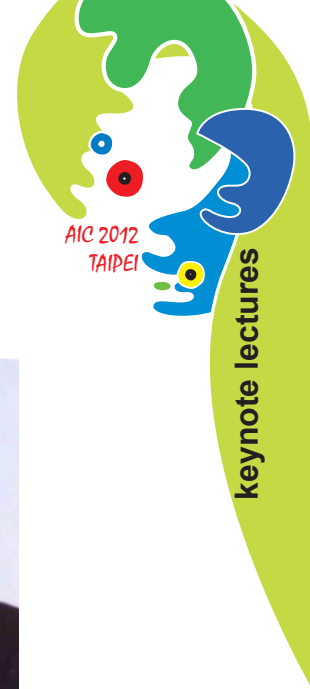
Axel VENN

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### ***Abstract***

Weariness about the current „Zeitgeist“ (spirit of the time) builds the foundations for new trends. The upcoming new is future-oriented and in all cultures more important than the old. Philosophy aims at tomorrow, psychology looks for the past. Trends always use archetypes of the past. The concurrent modern is therefore „genetically“ continuing the unmodern: trends follow a genealogically pre-determined trace. The talent to recognize future trends depends on endless curiosity, the seemingly endless ability to memorize experiences, and the subtle, perceptive skills of a Sherlock Holmes. Colors are the most articulate signals for upcoming new trends, and colors provide meaning and philosophy to things. Color trends add to the perception of a positive life style. There will be three main new trends for the next two years to come: the appeal for aesthetics, for design, and for emotions. These three appeals will influence the eight most important trend themes of the years 2013 and 2014, covering life-style, fashion, and products. There will be 6 main colors identified for each trend with three main colors and three additional colors for greater effects. Each trend will be introduced in its capacity of trend intensity and duration. Trend themes will mention classical and modern aspects of lifestyle, explain the importance of the play of light and shadow, and also relate to patterns and materials. A great influence of colors on personal comfort can be found in designs, like strict or flowery surroundings transferring messages of simplicity or freshness, and similar effects. Nature has its place within the upcoming favourite living worlds, carrying its abundant forms and flavours into people's homes. Colors of nature combine with modern habits of pleasure and convenience, adding to individual life quality and personal well-being. The indications for the new trends on the horizon promise to bring surprising, exciting, and fascinating new color worlds.



## **Prof. Monica C. KUO**

Prof. Monica Kuo is the Chair of the Digital Earth Research Center at Chinese Culture University (CCU), Taipei. She was the Dean of the College of Environmental Planning & Design of CCU and Member of the Urban Design Review Committee of the Taipei City Government, Taiwan, R.O.C., as well as a Member of the Urban Planning Commission and the Regional Planning Commission Ministry of Interior, Taiwan, R.O.C. Besides, she was President of the Chinese Landscape Architecture Society in Taiwan, Chair of the Department of Landscape Architecture at CCU, and Chair of the Environmental Committee at Zonta International. Prof. Kuo has presided as Chairman in international congresses concerned with landscape architecture, and has received several government awards for her commitment.



### ***Formosa Taiwan's natural color expression***

Monica C. KUO

Chair, Dept. of Landscape Architecture, College of Environmental Planning & Design, Chinese Culture University

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### ***Abstract***

Taiwan, situated in the north hemisphere and embraced by the Tropic of Cancer, exhibits a great diversity of geographical climates. From sea level to the highest mountain, Taiwan's topography reaches 4000 meters, giving home to a splendidly rich ecosystem in which landscapes such as tropical strand forest and temperate tundra prosper. Taiwan's ecological diversity also results in broad array of natural and cultural landscapes.

From the perspective of natural geography, this article presents Taiwan's landscape characteristics as viewed in different geographical climate zones. One major point will be addressing the quality of Taiwan's environmental color throughout four seasons. As Taiwan was traditionally called "Formosa," such a naming also displays its abundant biodiversity and landscapes.

9/25 Tuesday  
9:20 - 10:00





## The urban and rural environment – scaling outdoor scenes

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*John B HUTCHINGS, M. Ronnier LUO*

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### Abstract

In numerous cities internationally there has been a rise in civic pride through, for example, the creation of environments of sustainable development. These may be characterised by economic and social growth according to nature's ability to sustain that growth ecologically. The visually perceived scene is an essential component of this environment. If an area is to be passed on to the next generation in a better condition than we ourselves inherited, a successful protocol for its description is essential.

In this paper we suggest a protocol for scaling the outdoor environment using standard methodology of total appearance. Scenes consist of physical properties and the psychophysical and psychological responses they initiate. Interactions with an outdoor scene can be considered in terms of four elements all of which can be scaled. These comprise our perceptions of the physical properties of the outdoor environment, the psychophysical effects of our perceptions of the physical properties (expectations), the overall impact, and the psychological effects on us as individuals. Effects of actual physical data, determined by digital and visual imaging, such as traffic speed and town lighting factors can be built into the developed model.

The physical properties of the outdoor environment fall into two parts – the static environment (including buildings, decorative quality, trees, electricity supply lines, and routes through) and features added to the static environment (such as human beings, illumination and reversible additions such as litter and dirt). Expectations are the psychophysical effects of our perceptions of the environment in terms of visually assessed safety, identification, usefulness, pleasantness and satisfaction of the expected outcome. For specific applications we can scale for specific expectations, such as degrees of sophistication, comfort and intimacy.

The third property of the external environment is scene impact which can be summarised in terms of a model comprising degrees of warm to cool and hard to soft. The overall colour image can be summarised using the Green-Armytage descriptors of the colour impact. The fourth property of the external scene comprises the psychological effects on us as individuals. Among the scales appropriate for this property are degrees of happiness, relaxation and in control.

In this way we can develop a description of the, for example, town centre, in terms of the psychophysical and psychological responses of the inhabitant and the visitor.



## Chromatic mutations in suburban areas

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### Abstract

Urban sprawl produces hybrid territories, neither urban nor rural, which superimpose to old structures, hence creating very complex visual environments. Quite strikingly suburbanisation, which has been taking place over several decades, has also generated areas characterized by specific chromatic palettes, breaking radically away from usual palettes of traditional cities.

The important chromatic mutations occurring in suburban areas have not yet attracted much scientific interest. Most existing publications focus on the colour of historic cities, in search for heritage values and collective identities expressed by traditional colours. Therefore, the main purpose of this paper is to describe emerging chromatic palettes that can be observed in suburban areas so as to show how new colour arrangements, largely designed along market demand and offer, change our daily environment which influences consumers and residents behaviors. Two specific types of suburban areas will be investigated: “franchised” commercial zones and periurban housing districts.

Making its first appearance in the US, the commercial zone model (including shopping centers and entertainment areas) is closely intertwined with individual mobility. Located outside the city and connected to the road network, its basic requirements are accessibility, land availability and visibility. Saturated colours inspired from the world of comics and advertising are often being used to confer some form of visual identity to places and buildings. These are identifiable at great distance, because these colour codes are engraved in our memory as kind of “alerts”. In some cases, besides billboards, saturated colours even cover the entire building: the outer shell representing the brand and reciprocally the brand being identified by the façade. Such colour patterns have an impact on visual kinetics and space memorization.

Chromatic palettes of housing districts are basically the results of sociocultural and economic factors. The individual house symbolizes the dream of home ownership. Developers often use the same local picturesque palette of colours based on pastel shades with little variation. Many housing settlements are hence characterized by uniform chromatic palettes, even though the periurban model would somehow address a quest for more individuality. This illustrates the existing contradiction between the demand formally expressed by inhabitants and the resulting visual environment as provided by the market.

The process of urban sprawl is not expected to be reverted in a short time frame. The chromatic mutations described in this paper concern large urban fragments and develop very rapidly. As a result of economic development and globalization, a dilution of traditional colour models can be expected in the built environment. Our research is carried out and illustrated through examples from both scientific and professional publications, as well as from case studies conducted in our laboratory.



AIC 2012  
TAIPEI

oral paper

9/23 Sunday  
14:00 PM

## SYN-TES: interdisciplinary research on colour and light.

Karin FRIDELL ANTER<sup>1</sup>, Harald ARNKIL<sup>2</sup>, Leif BERGGREN<sup>3</sup>, Monica BILLGER<sup>4</sup>, Pär DUWE<sup>5</sup>, Johanna ENGER<sup>1</sup>, Anders GUSTAFSSON<sup>5</sup>, Cecilia HÄGGSTRÖM<sup>1</sup>, Yvonne KARLSSON<sup>5</sup>, Ulf KLARÉN<sup>1</sup>, Thorbjörn LAIKE<sup>6</sup>, Johan LÅNG<sup>7</sup>, Barbara MATUSIAK<sup>8</sup>, Anders NILSSON<sup>9</sup>, Svante PETTERSSON<sup>7</sup>, Helle WIJK<sup>10</sup>

<sup>1</sup>University College of Arts, Crafts and Design, Stockholm; <sup>2</sup>Aalto University, School of Arts, Design and Architecture, Helsinki; <sup>3</sup>Independent senior light expert, Stockholm; <sup>4</sup>Architecture, Chalmers University of Technology, Gothenburg; <sup>5</sup>Alcro-Beckers AB, Stockholm; <sup>6</sup>Environmental Psychology, Lund University; <sup>7</sup>Philips AB, Stockholm; <sup>8</sup>Architecture, Norwegian University of Science and Technology, Trondheim; <sup>9</sup>NCS Colour AB, Stockholm; <sup>10</sup>Health and Care Sciences, Gothenburg University  
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### Abstract

The interdisciplinary Nordic research project *SYN-TES: Human colour and light synthesis. Towards a coherent field of knowledge* was carried out during 2010-11. It deals with the interaction between colour and light and with their importance for human beings. Its starting point is that colour and light are inseparable in our experience of the world and that they together form our visual experience of space. Until now, colour and light have largely been considered as belonging to two different fields of knowledge, having disparate theoretical, terminological and methodological traditions. All this creates a ground for misunderstandings and obstructs a fruitful interdisciplinary and interprofessional collaboration.

A survey over international research literature from 2006-11 shows that there has been only little research on the spatial interaction between colour and light, but that the interest for this area has recently increased. Two large conferences in 2010-11 dealt explicitly with both colour and light, though most contributions still examined them separately. We therefore venture to claim that, seen in a contemporary international perspective, the transdisciplinary collaboration that characterizes SYN-TES is unique.

Within SYN-TES, colour and light experts from different academic disciplines and industrial branches have gathered in workshops and seminars to investigate different aspects of the spatial interaction between colour and light. SYN-TES has also included a number of sub-projects on more specific questions. SYN-TES has contributed to the formation of a new and coherent field of knowledge with the human experience of colour and light as its point of departure. The project has produced new knowledge that is fruitful for those who work with colour and/or light in their daily practice, by:

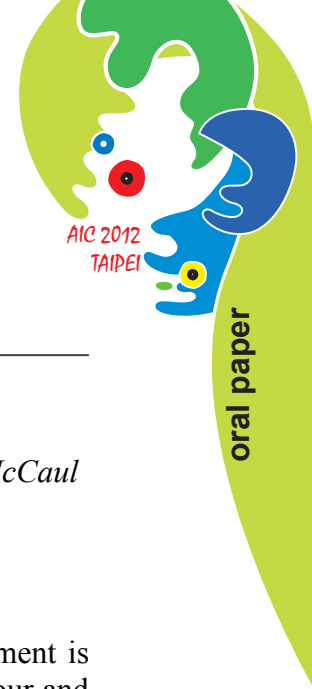
- development and explanation of concepts, supporting interprofessional communication
- contributing to understanding of the spatial interaction of colour and light, supporting design and architectural work
- formulating and testing pedagogical and analytical methods of colour and light in space
- developing and testing scientific methods supporting the research of colour and light in spatial interaction.

As part of the process, the group has found good ways of collaborating across disciplines and professions with mutual respect for each other's competences.

The results from SYN-TES are presented through:

- A series of Swedish language reports, addressing and designed for a broad readership
- A richly illustrated book in Swedish and hopefully other languages
- A scientific book in English, specifically dealing with concepts and conceptual confusions
- International conference reports and scientific articles.

After completion in 2012 the project lives on as *SYN-TES Nordic Interdisciplinary network on Colour and Light*, open also for others than those who participated in the project.



## Colour and light in the re-imagined birth environment

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### Abstract

Practice-based research on colour and light in the urban hospital birth environment is the focus of this paper. Recent studies offer new evidence on affect/effect of colour and light upon human health and wellbeing – from circadian cycles to hormone production; sensory, emotive and synaesthetic experience; physiological and neurological response, and more. This research proposes that current colour/light research across multiple disciplines might offer new insight of value for the birth environment. It further develops my previous research on colour/light potential to contribute to local and personal connection with nature/sense of place and patterns/rhythms of sky and cosmos. It questions how artificial and natural colour/light might be approached as sensitive partners in ‘salutogenic’ design.

The hospital maternity environment – today the predominant site for birthing in developed countries – is a contested and complex site of human becoming/being. One of the few medical spaces that anticipates joyful experience, it may suddenly become a place of decisive action in crisis. It holds, always, the dreaded possibilities of grief, of ‘failure’. How are these emotional aspects of birth reflected in the environments we create for mothers, babies and supporting participants? ‘Medicalized’ vs. ‘normal’, ‘scientific’ vs. ‘natural’, ‘safe’ vs. ‘risky’, ‘male-dominated’ vs. ‘woman-centred’, ‘scheduled’ vs. ‘spontaneous’...the terrain of ‘birthing’ is a global subject matter of vigorous research, debate and difference of opinion. This research posits that *the actual physical and, perhaps more importantly, the ephemeral environment (including its invisible sensory properties)* hold rich potential for forming/transforming human experience, and therefore are of importance to the development of birthing centre approaches in the 21<sup>st</sup> century.

As this research seeks imaginative evolution of our design approach to the spaces for birth in a medical setting, I question how new understandings of the mind/body relationship to environment might influence the phenomenological, temporal, interwoven ‘finding/making of meaning’ which humans engage in within this space/place. My work ponders the relationship between visual and sensory, material and immaterial aspects of place and space, and the felt/perceived/remembered birth experience.

This paper offers a study of a heuristic personal practice with transdisciplinary perspective - exploring/imagining the birth space as a poetic and enveloping site of entry into human life. The author (artist/designer/researcher) engages a narrative, reflexive methodology to represent work/findings across disciplines/practices, juxtaposing and synthesizing visual/textual and practical/theoretical research processes. The results provide initial elements of a ‘pattern language’ that may be seen as a paradigm shift in design concepts for the hospital birth environment.

9/23 Sunday  
14:20 PM



AIC 2012  
TAIPEI

oral paper

9/23 Sunday  
13:20 PM

## From Charles Henry to Julio Le Parc: experimental research on colour, light and motion

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Verena M. SCHINDLER

Art and Architectural Historian

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### Abstract

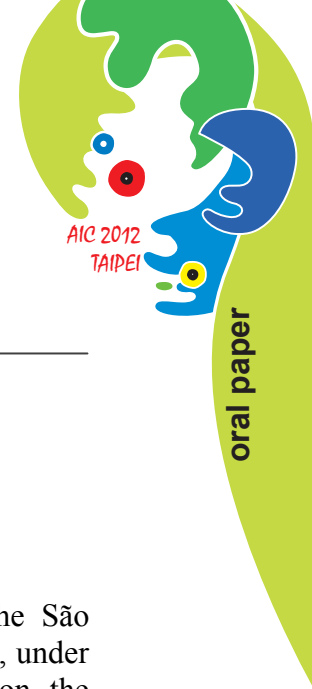
This paper inquires into the theory on colour, light, motion and visual sensation of the French scientist Charles Henry (1859-1926) and its impact on the pointillist painters Georges Seurat (1859-1891) and Paul Signac (1863-1935). Basing his approach on psychophysiological and aesthetic principles Henry developed a set of universal laws on contrast, rhythm and measurement. In particular, he assigned a 'direction', i.e., a degree of *dynamogeny* or expansive energy, to each colour. His colour circle—the sum of all directions—was the representation and symbol of all harmonies and contrasts or 'complementarities'. Intended to serve as an instrument for finding colour consonance and dissonance in the applied arts, this circle is constructed so that colours correspond to rhythmic numbers. This paper discusses his approach to light and colour as related to optical illusions and kinaesthetics or—in Henry's words—continuous and discontinuous ('*dynamogenous*' and '*inhibitory*') movements.

This paper then deals with the influence that Henry's ideas had on the experimental aesthetics of purist painters Amédée Ozenfant and Le Corbusier during the 1920s. Claiming that scientific investigations on colour and optics were fundamental to their artistic approach, they published Henry's ideas in the avant-gardist revue *L'Esprit Nouveau*.

Finally, this paper explores how more recently the Argentine artist Julio Le Parc, based in Paris since 1958 and one of the founders of the *Groupe de Recherche d'Art Visuel* (GRAV, Research Group on Visual Art), adopted some of these ideas, especially in his series 'Alchemie' painted in the pointillist technique in which small dots of pure colour are applied. In particular, Le Parc's 'Alchemie 123' conceived in 1990 is a poignant interpretation of Henry's colour circle and his principle of *dynamogeny*.

In sum, this paper discusses artistic-scientific research as related to colour, light and motion—the unstable and the aleatory versus rigor, precision and calculation.





## Livecolour colourinhabiting in são cristóvão, portugal

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### **Abstract**

“LiveColour Colourinhabiting” is the name of the action taking place in the São Cristóvão village, Alentejo, Portugal, and is the case study of my PhD in Design, under the theme –Collaborative Paintings in Residential Facades. In the Alentejo region, the chromatic culture of the rustic houses is characterized by the white in the backdrop of facades, that according to Gil (2010), it was followed from the Islamic tradition, settled by 19th century hygienist culture, and using the colour in the frames of doors, windows and footers, as a differentiating parameter of social classes. The act of painting returns every year, keeping the ritual that solidifies this culture, even though the synthetic paints replaced progressively the whitewash and natural pigments. The total white application in the facade panels, as something that “has always been”, has been discussed, however, nowadays this is the image installed in the collective memory, Aguiar (2009). What happens then, when a draft for a collaborative action is presented, that proposes painting the residential facades of the village with designs that try to express individual identities and a new local identity and aesthetics, pointing a new image and environment for the public space? Having as theoretical horizon the concepts given by Max-Neef (1982), that pointed to the need of each individual participation in the effective construction of the space that he inhabits, forming, like this, their own identity; and according to the sustainability concept proposed by Ehrenfeld (2008), where the self development is primordial; the research done in São Cristóvão, evolves with the intention to provide stimulus for a more integral development of the individual and the society.

So through an interventionist methodology, in immersion with the population, is requested that each participant brings personal objects that have affective and aesthetic relevance and a registration of oral tradition or an individual thought, to be shared. These elements, later worked by me at the office, will result in a set of drawings in a path’s logic, which after painting, will generate a singular and renewal image to the village facades, redeeming memories, and revealing the current worldview of its actual inhabitants, satisfying some of the human needs as defined by Max-Neef (1982).

How was made the negotiation of the immaculate white with the new formal elements and poetic texts, in the face to this cultural trait so stricken? Actually what human needs are satisfied besides the construction of identity? Will it express any change to the economic and social level or an added value at landscape level? These are some of the issues brought by “LiveColour Colourinhabiting”, mirrored by change on the inhabited walls, where the colour is also protagonist of this transition that puts back the attention in place and on the human environment.

9/23 Sunday  
13:40 PM





## The Color expressions in the traditional costumes of the Taiwanese indigenous peoples

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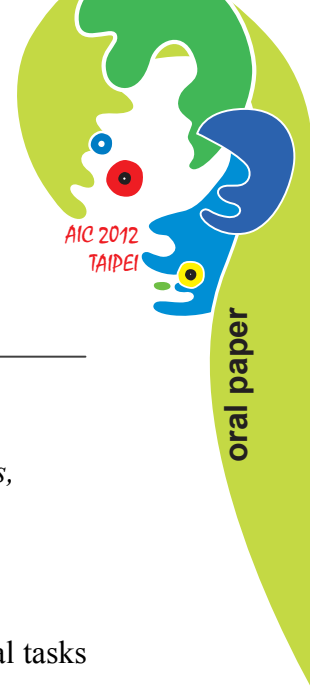
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### Abstract

The colors preferably used by the Taiwanese aboriginals are obviously expressed through both of the embroidered and tattooed textures on their traditional costumes: the different expressions of textural colors present the different tribes of their uniqueness. With the fieldwork methodology, the paper attempts to contrast and analyze the colors and the embroidered textures through the costume samples that the researcher collected within the three years. The costume colors from different tribes, despite the diversity the tribes represent, have some colors mutually shared among the tribes, such as the colors they constantly use, red, black, blue and white. These colors have, along with other colors and textures, become their unique visual image.

The colors that the Amis people (an indigenous people of Taiwan) constantly use are black and deep true; the Atayal people and the Saisiyat people constantly use red, black, blue and white; the Paiwan, the Rukai, the Puyuma, the Tsou, and the Thao prefer black, red, and white; the Yami and the Bunun tend to mix black and blue. Due to the fact that the indigenous peoples live close to the Han people (the major population who live in the cities or countries in Taiwan), the accessories and the colors among the tribes will get mutually mixed and influenced. For example, both the northern and central Amis people usually wear the sword-like panel skirts, while the northern Amis people usually wear the flower-embroidered one-piece skirt. The major female costumes use red and black. In the recent ten years, the Bunun people massively use golden color to highlight their costumes. The costumes of both the Tsou and the Thao peoples are quite similar. Thus, we may tend to conclude that the colors used on the costumes among the tribes will vary with the lapse of time.

In the old times, the primordial materials for the color were derived from the root of the plants and then boiled them with the sap extracted of them. For instance, the sap of the *Dioscorea matsudae* can be used to dye to brown color, the dust sap, the mud or the *Manihot esculenta* pounded can be used to become black strings, the ocher was derived from the dust sap or the bulb of *Manihot esculenta*. Moreover, The dye color and plants that Atayal people use are, for instance, red brown from *Dioscorea matsudae*; black from *Dioscorea matsudae*, mud, and black mud; black brown from *Lagerstroemia subcostata* and mud; yellow from *Curcuma zedoaria* and *Gardenia jasminoides*; blue from *Selaginella uncinata*; white from the dust of *Trema orientalis*, green from the leaves of *Pilea plataniflora*, *Amischotolype hispida*, etc; yellow from *Calocedrus macrolepis*, blue from *Clerodendrum trichotomum*, red brown from *Dioscorea matsudae*, etc. From the data collected, we may tentatively conclude that the colors the indigenous people use may somehow be limited by the environment around them.



## The language of color in textile design

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### Abstract

We live surrounded by fabrics, and the chromatic choice is one of the fundamental tasks of the textile designer.

For a long time the decisions about the materials to be used, for both fibers and colorants, have been defined by the availability of them. In these textile productions the references to their origins –a certain natural geography and culture-- are underlying.

Different places are characterized, affected by the climate and the development of social activities, for different types of fabrics and dyes.

Currently with the myriad of synthetic materials which are available almost everywhere in the world due to global trade, both information and material (in addition to revealing the rapid development that alters the intrinsic organic substances and multiply them) open up to unimaginable possibilities for design. The opening that originates from the techniques, technologies and compositions, implies some awareness about the elections of the materials and the ways of using them.

With less or more knowledge about the intention of the fabric, its generation communicates. Color in textiles communicates. In some cases it communicates availability, in other cases it communicating design objectives, some codes, functions or roles, identification, beliefs, technologies. . . With so many options, design choices can no longer be naive.

In order to decide the color composition, the textile designer, depending on the context of development, has to face different variables. The environmental considerations to be taken into account are the traditions, history, trends and fashions, i.e., the social codes.

These colors codes embedded in the "communication" of textiles, allow deducing that there is a language, there are ways and meanings.

The senses are as flexible and mobile as textiles themselves traveling the world and times; but certain criteria to be observed could lead us to understand valuations and decodings. Also, to conceive that some communication occurs through the colors of fabrics, allows enhancing or empowering this language.

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14:20 PM



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14:40 PM

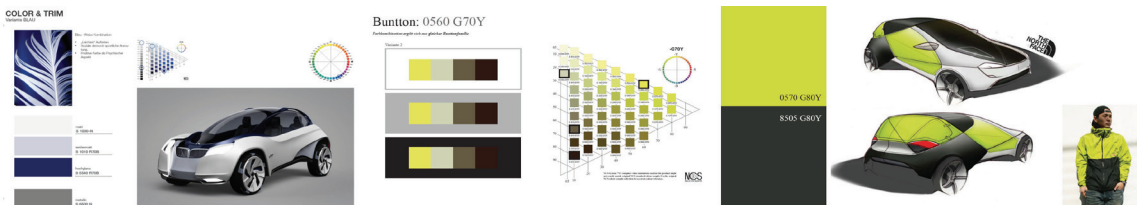
## Colour in industrial design

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### Abstract

Since the industrial revolution, serially manufactured products have increasingly determined our environment and culture. Industrial Design (Product and Transportation Design) is concerned with the functional development and the design of (industrially) manufactured commodities and investment goods. Industrial Design is oriented towards people and their diverse physical and psychological needs. It is purposeful and innovative; it aims to encourage consumerism and helps to differentiate products and companies. A key issue of the design process is the question of how and which design elements/means can best translate various user needs and manufacturer intentions into concrete product performances. The following (simple and complex) design elements/means can be distinguished and used in industrial design: material, form, colour, light, surface (haptic, visual), sign (optical, acoustical), virtuality, functional principle, construction principle.

In this paper, we will take a closer look at the potential and the various functions of colour in industrial design, analyse its interrelation with other design elements, and suggest ways to improve the understanding and handling of colour during the design process, both in education and in practice. At AIC 2012 I will present and discuss several case studies from the Industrial Design course at the FH Joanneum U.A.S. Graz/Austria, where I have been teaching since 1995.



Colour and form: the relation between colour and form is particularly interesting. Although colour and form together make up the Gestalt, form is generally given priority in the design process. This approach, frequently criticised by colour theorists in architecture, seems to be much more plausible for industrial design. Many commodities and investment goods must first of all fulfil physical functions, and often include a high degree of haptic interaction. Under this premise, form-finding should come first. Unlike colour, the form of things can be discovered using more than one sense – that is, with touch and sight. So at the point where form is also regarded as a visual property of an object, the question of colour can no longer be excluded. Colour can make huge optical changes to form, but form cannot change colour correspondingly. How colour contributes to the function of an object also varies greatly. For example, one could hardly make a football angular, no matter what colour it is; the colour grass-green, on the other hand, has no effect on the physical function of a ball, but would make any football match impossible.



## Colour shift behind modern glazing

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### Abstract

The necessity of a dramatic reduction of energy consumption in the building sector causes the need for much higher energy efficiency. Regarding facades, the easiest way to obtain this goal in many European countries, e.g. Norway, is to reduce the size of windows. On the other side occupants need a considerably high daylight level, visual comfort and a nice view out. How to meet those contradictory goals?

New glazing technologies and new translucent materials are under development, for example the nanogel material that has an exceptionally high thermal insulation capacity and a moderate light transmittance. Can those new materials and/or technologies help us to meet the goal?

In the scientific project Translucent Facades a number of new glazing types equipped with especially designed low-energy coatings and new translucent materials were studied regarding: light transmittance, light distribution and glare. During the work with the glazing samples a clear color difference between the outside and the inside appearance of samples was observed. This was a cue to regard glazing samples as a sort of color filters and triggered the research group to test color shift in interiors situated behind such glazing; the “colour shift” project was defined.

The main goal of the colour shift project was to explore in which direction (hue? chromaticness? blackness?) and how much do different colours change their visual appearance due to a given glazing type. The NCS colour system was used: five hues in addition to the nonchromatic grey scale were chosen; 5 different nyances were chosen for each hue. The study was carried by expert observers in a specially designed scale modell 1:5 consisted of two rooms: a reference room and the test room to which the respective glazing types were fixed. The project was carried in the Artificial Sky, NTNU, the overcast sky simulator, where the correlated colour temperature is 6000 K.

The project had two stages. In the first one the effect of single-layer, double-layer and a low-energy tripple-layer glazing was compared to no glazing. In the second stage the nanogel and heat mirror materials were compared to the tripple glazing from the first stage. The results from the first stage demonstrate that a single-layer of standard float window glass has no significant impact on the perception of colours. A double-layer glazing may have a small impact for light nuances especially if they are viewed at a dark background. In the case of tripple glazing a considerable colour shift was registered for light nuances of all hues; e.g.: S 0510-R on a black background: hue-shift 30%, chromaticness 0%, and blackness 10%, all of them measured on the NCS-scale. Also the results from the second stage testify significant colour shifts for light nuances of all hues, especially due to the nanogel material.

In addition, the research group developed a new method for graphical presentation of colour shift that may be interesting for the AIC society.



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oral paper

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10:40 AM

## **Colorfulness and reflectivity in daylit spaces: Quantifying indoor color reflectance in terms of experience and performance**

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### **Abstract**

This research paper focuses on the connection between daylight and color reflectivity in understanding how to optimize reflectance in indoor spaces to improve lighting efficiency and visual comfort. Buildings consume 70% of all U.S. electrical energy production, most of it for electrical light. Therefore daylighting is an important strategy both to save energy and reduce greenhouse gases that cause global warming.

Reflectivity is not only valuable architecturally and aesthetically but also in terms of performance.

- Daylit spaces with high reflectivity distribute light better and are perceived to be brighter. As one moves away from the window plane, the available daylight in the room is provided decreasingly by the sky and increasingly by the reflectivity of interior surfaces. Increasing reflectivity can reduce the need for electric lighting, resulting in less electrical consumption during daylight hours.
- Spaces that have high reflectivity have a lower contrast between the brightness of the daylight from the primary source (window) and that from secondary sources (interior surfaces), resulting in better visual performance and comfort.
- Color experiments indicate that designers/people overestimate the brightness of colors and can't gauge their light reflectivity by just looking at a color or surface.

Given the benefits of reflectivity, why are rooms not typically designed with more reflective surfaces? Our aesthetic valuing of dark rich colors conflicts with the high reflectivity that is more effective for daylighting. Reflectivity index apertures can improve the performance of a building's system by making daylighting more effective and can increase occupants' sense of well-being by distributing light more evenly.

This paper describes experiments I conducted on color perception and performance. reflectivity and examines the topic historically using a timeline that shows interactions between scientific and artistic thinking about color. The paper asks why color reflectivity in interior daylit spaces has not been identified by architects as a research topic, given the potential it has for increasing energy efficiency and comfort. (Words 314)





## Wide area color signal estimation from reflected image on cornea surface

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### Abstract

This paper proposes a method for estimating the wide area color signals of the surrounding scene from the reflected image on a cornea surface.

When we observe human eyeballs, we notice that the surrounding scene is reflected to the eyeball surface as an image. A part of incidence ray from the scene is specularly reflected on the cornea surface, while the other part is transmitted into the inside of the eyeball. The specular reflection image on the cornea surface includes useful information about the surrounding scene. Since the cornea surface is considered as a part of a mirrored ball, we can obtain color images of the surrounding scene in wide viewing angle.

The conventional methods used a mirrored ball or a fisheye lens as an optical tool to capturing the wide area images. Although such a capturing system makes a precise distribution of wide area color signals from one image, the system requires specific and expensive devices and careful calibration. In this paper, the eyeball is used instead of the mirrored ball to solve the problem. It has a merit that we can estimate the wide area color signals in a simple measuring system without the specific devices and calibration. In addition, this method has a variety of applications in the image technology field. For example, suppose that we have high-resolution images taken before, including human faces. If the camera spectral sensitivities are available, in principle we can recover the surrounding scene from the reflected eyeball image and estimate the wide-range color signals.

The shape of the outer surface of the cornea can be approximated as a sphere. The radius of corneal curvature is assumed as 7.8mm which is the average length of the adult's corneal curvature. Because the cornea is transparency and smooth, it behaves like a window glass. The specular reflection image on the cornea surface has the wide visual field of about 160 degrees. We apply the Wiener estimator to estimate the spectral distribution of color signals of the surrounding scene from the reflected image on the cornea surface.

In experiments, we use the Canon EOS 60D as a commercial high resolution RGB three channels camera to take the reflected image on the cornea surface. Each color channel is represented by 12 bits, and images are sampled on a 2052×3088 pixels. Then, the estimated spectral distribution of color signals are compared with the direct measurements by a spectro-radiometer and the estimates by a mirrored ball. For the detail analysis of estimation accuracy, the Macbeth Color Checker is placed in front of a subject. We extract the cornea from the subject's face image and estimate the color signals from the respective color patches. We confirm a good accuracy of the estimation results in comparison with the results from the mirrored ball. Finally, we examine the feasibility of the proposed method under natural environment so as to show that the method can provide reliable estimates of the wide area color signals without using specific devices and calibration system.

9/24 Monday  
11:00 AM





## The inconstant colour of green

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Gertrud OLSSON

KTH School of Architecture, Stockholm

### Abstract

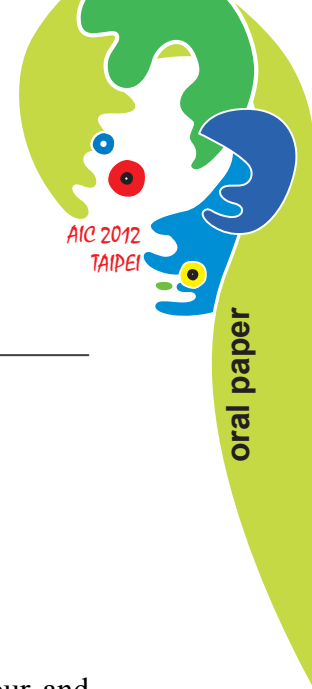
Studies of colour in space are complex. Many components need to be considered. Thus, the experience of a colour depends on a number of things: the individual's colour vision, illumination, the way the light is reflected, colours meeting in different distances in the room, the colours on various materials, colour phenomena, colours of adjacent surfaces and their surroundings. The subject of this paper is the inconstancy, the non-solidity of a colour hue.

In physics, the *Uncertainty Principle* is an established concept. Quantum mechanics – the branch of physics that examines reality at the atomic and elementary particle level – can predict *probabilities* but never know with certainty what happens to the particle being observed at the micro-level outside the established laws of nature (Zukav 1983). The only thing that can be determined is what we observe directly in the very moment of observation, according to the German physicist Werner Heisenberg. We know what we have when the observation begins and when it ends, but we cannot speculate on the events in-between (ibid.). The Heisenberg Uncertainty Principle is the result of nature's ambiguity, that is, that the various processes of nature are characterized by uncertainty. The particles being studied are also affected by the study itself. This relation of uncertainty can be translated into the consideration of colour. Since colour tones shift, regardless of the method of study and other circumstances, the colour can only be determined in the particular moment that the colour is being observed.

The French philosopher Maurice Merleau-Ponty brings forward an idea of perception as an unreflected experience (Merleau-Ponty 2004). His phenomenological philosophy focuses on perception, on how we apprehend colour in space and describes perception. We take in and perceive the world, he says, as a *reduction* (Merleau-Ponty 1967). Here, "reduction" means that perceptual impressions are limited, the sensations are held together by colour. For example, via a repainted wall, the things are gathered together into a common perception. A link can be established between nuances and other coloured things. Therefore, a dress is bound up with and interacts with – in its various materials, fabrics, and fibers – other red hues.

In a course this semester, *The 5th Dimension: Colour in Architecture*, at the KTH School of Architecture in Stockholm, the student's assignment was to analysis an allotted colour on a sheet of paper. Their task was to examine and pay attention to the specific qualities of the colour sample – for example, a blue colour is never only blue. The colour has a shade of darkness or lightness, and the blue hue can move towards green or red. The students should derive the colour historically and geografically from different epochs and cultures. In addition, they must consider how the searched colour might be used today.

A group of students chose a soft, light and inconstant green colour; with their own expression a *non specific green*. Some green hues are bluish and some green are yellowish but this green can change in all directions. The group of students staged a short urban experiment using the green colour by creating a film sequence (Almeida and Pinto Rocha 2012). In this paper, via the student's work, I want to evoke and highlight this quite anonymous city colour in everyday public space. The examination will be discussed in line with the theories of Heisenberg and Merleau-Ponty.



## Always something else - levels of experiencing colour and light

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### Abstract

This paper springs from a project about concept formation in the field of colour and light, and presents a graphic model describing possible constituent relations between different kinds of colour and light experiences.

Humans see colour and light, but what they so vividly, experience is a coherent spatial world full of life and meanings.

The human comprehensive experience of colour and light has many sources; the given cultural context, the direct experience of the world around and – not least – the basic perceptual functions. A deeper understanding of colour and light experiences calls for a coherent and well-defined structure that can be used to describe connections and distinctions between different kinds of experiences. This can also contribute to understanding of how colour and light concepts are related to each other.

The basic relations between different levels of experience can be described in a graphic model with three concentric circles, where the two inner circles represent categorical perception and the direct experience respectively, and the outer circle stands for indirect experience culturally transferred through history, traditions, customs, trends, scientific theories, art, poetry, etc. Categorical perception is in some respects determined genetically, but for the most part acquired in early life.

The basic experiences of colour, light and space are parts of the categorical perception, the aim of which is to build a comprehensive mental image of the world. Interplaying with the physical world humans gradually learn through living how to recognize and understand colour and light in the world around.

Concepts are abstract and thus they belong to the outer circle. Dependent on their origin, they have indirect or direct relations to the two inner circles. Concepts used for specifying spatial light situations or perceptual light qualities and concepts used in perceptual colour theory aim to describe a direct experience. Concepts based on physical analyses with *quantitative measurements* and *instrumental* methods have an indirect relation to perceptual phenomena.

The three experience levels are mutually dependant and implicitly present in all perceptions. A perceived distinction between a red colour and other colours is a basic perception. The experience of the colour of a wall – whether in light or shadow – is a direct experience of the world around. The knowledge, that red has a special position in a colour system or that red surfaces absorb electromagnetic radiation in a special way or that red houses may be of high social importance, is based on indirect experience.

Our experience of the world is a coherent whole, but colour and light have many aspects. They are “always something else”, and their relations to different levels of experience always have to be considered.

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oral paper

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## Color naming experiment using plural color stimuli under different viewing environments

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### Abstract

Color specification by color names is considered a higher level of representation of color perception. It is important to investigate color vocabulary not only for the color field of science but also for other fields of like linguistics and ethnology. In conventional color naming experiments using a priori clues, color patches were generally used under a standard illuminant condition. However, in scenes from the real world, most objects are 3D and this can generate illumination effects such as glosses, shading and shadows on the surfaces of the objects. These are observed in different color appearance modes such as the aperture and the surface color modes. In our previous work, reported at the AIC2011, we investigated the relationship between 2D and 3D rendered samples on the basis of the frequency of 15 color terms in modern Japanese and the reaction time.

In this paper, we investigate the relationship between color terms and color appearance modes based on psychophysical experiments. In conventional psychophysical experiments for analyzing modes of color appearance, a single color stimulus on different background colors is generally used on display devices and in scenes from the real world. However, in our daily life, we are surrounded by colorful objects in different color modes. In our experiments, we used sets of plural colors of 90 PCCS patches as test color stimuli; and analyzed the effect of the modes for color appearance on color perception. First, we developed a color term collection system using a calibrated monitor and a personal computer. Second, for all test color samples, we prepared various test environments by changing the following conditions: (1) two visual media (monitor and real patch), (2) three background colors (black, gray and white), and (3) two color representations (ordered and random). For the ordered representation, plural color stimuli were given in color tone order. For the random representation, plural color stimuli were given regardless of color tone at random. We then performed fundamental experiments with five native Japanese people in the darkroom for the monitor and under a  $D_{65}$  light source for real patches. The subjects answered the most appropriate color name from the 15 color terms for each of the color samples.

As a result, there was no significant difference between color appearance modes for color term perception. This result suggests that color naming is robust for the visual media, the background colors, and color representations. However, in the following two opposing conditions, partial color term transitions were observed: (1) Using real PCCS patches on a gray background (surface color mode), and (2) Using a monitor with a black background (aperture color mode). Furthermore, by using plural color stimuli, we found that the color naming changed depending on the color representations, which were ordered and random conditions, in each color mode. The result suggests that we should consider effects of spatial properties for color naming in the real world. (479 words)



## What is a natural color? Natural colors and consumer expectations

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### **Abstract**

The purpose of this paper is to explore some relationships between color and the expectations of the user/consumer, regarding the concept of what is natural.

We have been developing a program at university whose main goal is not only to introduce design students to the study of natural dyes but also to impart knowledge that can contribute to the use of natural dyes as added value in textile products design.

In a preliminary survey, we tried to find answers to the following questions: What is a natural color? What is a natural colorant? We could observe that the concept of what is “natural”, apart from the obvious relationship with nature, was associated to certain hues and to certain color perception linked to a feeling more than to an objective description.

The concept of purity appears to be linked to both material and symbolic factors. There is a clear dichotomy that contrasts natural-pure-unpolluted-ecological with industrial-chemical-pollutant. If we consider the categories of the expectations described by Hutchings, the colors defined as natural appeared as visually assessed safety.

We decided to determine with greater precision what aspects of visualization of the textile product are perceived as more “natural”, given the positive assessment associated with such concept. To that end, a first broadening of the survey is being implemented, using a scale of semantic differential (more natural – less natural) applied to a group of ten colors, to five hues of the same color and to five samples of different textile materials of the same color.

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10:40 AM



## Interior colour design effects on preferred level of light

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### Abstract

Colour and light are functionally inseparable in our experience. Understanding their interaction is essential for creating good environments for human life. In this study we focus the relationship between interior colour design and preferred level of light.

Previous research suggests that the spatial organisation of coloured surfaces in a room can affect the perceived level of light. We assumed that it could also measurably affect the preferred level of light. Applying concepts from the *Colour-Shape Interaction Analysis* we formulated the hypothesis that, compared to a uniform colour design, the preferred light level would increase significantly when applying countershading colour design and decrease significantly when applying co-shading colour design.

This pilot study used a test room equipped with two sets of luminaries, creating one un-directed and one clearly directed lighting scenario. Walls and furniture were repainted three times to give us first a uniformly warm-grey room, then a countershading and finally a co-shading colour design, still warm-grey. Interior decoration details were added to create a more normal semi-private atmosphere.

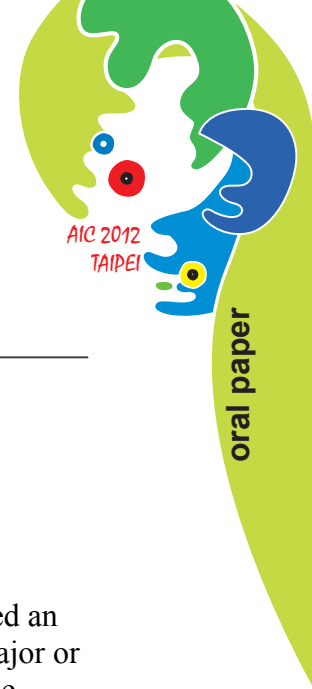
The test included 29 observers, male and female of varying ages, participating through all the study. To overcome the differences between personal light-level preferences we analysed the results by comparing each person's results with his/her own in the different experimental situations.

Each lighting scenario was judged separately. The observer used a dimmer to increase or decrease the total level of light. Between every visit to the test room the observers spent approximately 5 minutes in a, by blinders and complementary artificial light, reasonably controlled daylight room.

Two different situations were judged every time the observer visited the room. First the observer was asked to move around in the room and dim up/down to the lowest acceptable level for "staying in this room a whole day without doing anything particular". Next, the task was to set the most suitable level when sitting by the table, looking at pictures in glossy magazines "as if you were going to make a collage of them". Both situations were judged twice in each lighting scenario, starting from completely switched off and from fully turned up light.

The energy consumption for each judged situation was registered with a watt-meter. Watt-values were later recalculated into mean lux-values based on measurements from 103 points (33 on floor, 70 on wall) at 4 different watt-levels for each scenario. Data were analysed statistically.

In our result, countershading significantly increased the preferred level of light, but the assumption that co-shading decreases the preferred level of light was contradicted. We suggest that this negative result does not really falsify half of the hypothesis, but may instead be explained by unforeseen difficulties to accomplish a functioning co-shading design. It may be like clapping hands in time with music – there are innumerable ways of clapping out of time, but only one way to do it precisely in time. Thus ongoing additional studies compare the function of co-shading in concave rooms with that on convex objects.



## A new method to correlate music and colours

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### Abstract

This study is based on the research of L. E. Eberhard, 1884 – 1972. She developed an authentic method to correlate music and colours. The classical musical keys in Major or Minor with their specific intervals were used to match colours. The purpose of the method was/is to define and sort harmonic colour combinations objectively. L. E. Eberhard's method is documented in her book and coloured tables:

<http://www.colourmonics.de/index.php/farbsysteme.html>

This paper wants to examine the underlying hypothesis of L.E.. It also tries to provide a versatile method to test music-colour correlations in general.

1. An in depth literature review was done. It resulted in a coloured overview table comparing 28 music-colour correlation approaches/attempts of the past four centuries: <http://www.colourmonics.de/index.php/farbsysteme.html>

The scientific literature provides no consent on the mathematical conversion of the wave lengths of colours to the frequencies of sound. Human physiology obviously does not allow for it!

Therefore this study is limited to the correlation of the interval structures of music to 360 degree colour circles.

2. An innovative software (CHSoft 1.0) was developed in order to test and vary the hypotheses of L. E. Eberhard: <http://www.colourmonics.de/index.php/chsoft.html>. The software allows for the analysis of the interval structure of the colours of any object, picture or scene. The results can be grouped and archived for review by researchers and test persons.

A special feature of the software is the high degree of adaptability. The colour of any of the 72 keys of the on screen keyboard (three octaves with 12 keys each plus the ¼ step keys in between = 72 keys) can be changed easily. The hue, lightness and saturation are all changeable. Thus a multitude of different assumptions concerning the correlation of music and colours can now be tested by anybody interested.

3. The results using this software are preliminary. The colours chosen by L. E. appear helpful in defining and sorting harmonic colour analyses. The colours of the living nature, of plants and animals, were strikingly often found to be harmonious.





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oral paper

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13:20 PM

## Color in the Argentine Delta House

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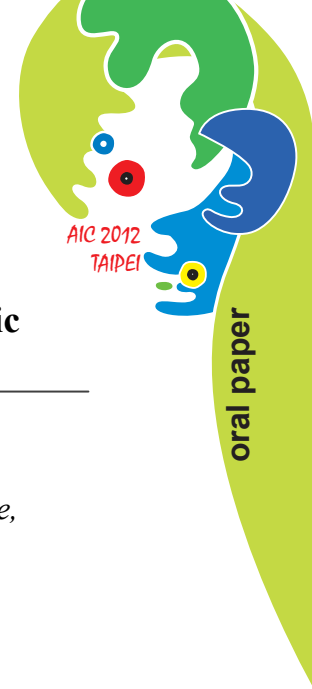
### Abstract

The Argentine Delta, an active delta, that grows constantly, is an unspoiled natural phenomenon, resulting from settlement of fertile silt and lush vegetation on a vast archipelago of 40,000 km<sup>2</sup> at only 32 km. from downtown Buenos Aires, where many have chosen to live, permanently or temporarily. Stilt architecture is the dominant architectural feature of the Parana River Delta, developed to survive the flooding of rivers.

The earliest inhabitants of the islands were indigenous. After 1580 the lands had been distributed to Spanish colonizers. Tree centuries later, the area was sparsely populated when D.F. Sarmiento inspected it. He constructed the first of the typical wooden houses now seen throughout the Delta. He was instrumental in the development of the area. During the second half of the 19th century the islands became economically important when the country underwent a significant immigration process and part of those immigrants settled there. Houses were made in wood or plastered brick. Colors were most the white of the whitewashed walls, creamy colors and that of natural wood. In some cases color was used for some decorative detail.

At the beginning of the 90's a remarkable increasing of temporary population led to the construction of new houses, with the electricity and telecommunications diffusion. The use of color in home exterior also increased as results of paint manufactures campaigns. In 1990 arrived in Argentina the Tintometric Color System and was introduced to the market in 1991. This system affords the possibility of preparing an extensive range of colors in a simple way. It is very useful when real artisan painters disappears to leave place to people that know about technical aspects but not too much about color. The "paint boutiques," were equipped with terminals which enabled customers to look at the house exterior they wanted to paint. This was a real motivator of the the use of color in houses exterior. This process was accompanied by others actions that improved the knowledge and use of color. Foreign companies began to propose special color charts for Argentina, settled after the discussion with argentine specialists, and also information about color meaning and trends.

The impact of all this actions is evident. Dialogue between nature and houses in t he Delta is now extremely rich. Yellow in the first place, follow by pink are very often seen, but orange, green, blue, lilac and even violet won now the facades. Large houses, when painted, continue to be mostly in white or creamy and very light colors but small houses appear as colored jewels in the greenery surroundings. Colors made by the creativity of the architect or owner's own fantasy already belong to the cultural patrimony of the region.



## Brightness evaluation for a room furnished with various chromatic objects

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### Abstract

Several studies have proposed perceived brightness evaluation systems for a lighting environment based on measuring a luminance distribution of the scene. These methods are powerful tools to evaluate a lighting environment which is difficult to estimate the perceived brightness only by measuring a horizontal illuminance. Other studies showed that, however, perceived brightness of a room with chromatic interior decorations was different from that with achromatic, although the luminance distribution was the same. Thus, to estimate a brightness of a colored room, not only luminance distribution but also chromaticity distribution must be required. The purpose of this study is to evaluate the effectiveness of colored furniture on perceived brightness subjectively, and to examine the relationship between the color effect and photometric chromaticity distribution.

We examined the effect of chromaticity and number of colored furniture by brightness-matching method. Subjects were presented a couple of miniature rooms that were different in terms of chromaticity of interior decorating surfaces, but kept lightness of surfaces constant. Subjects were asked to set the illuminance of reference room, that is furnished with achromatic objects, to equate the brightness of the test room, that is with chromatic objects. Subjects needed less illuminance to get the equality of space brightness if the test room had saturated objects. For the most saturated test room, the illuminance ratio of test to reference room was about 1.4. In the same way, the more colored furniture the test room had, the brighter subjects perceived a room.

To obtain chromaticity and luminance distribution of the room we developed a colorimetric system with CCD. This system provides us CIEXYZ distribution with visual field of 180 x 180 deg. The error between the actual measurement values and the predictive values were about 5%. To establish the estimation method of perceived brightness by the CIEXYZ distribution, the effect of area of chromatic object and difference of chromaticity between test and reference room were discussed.

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## Interaction of color and taste: Color synaesthesia in the food environment

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### Abstract

Synaesthesia is a phenomenon by which associations between different sensory channels are produced: stimuli received through one of the senses are interpreted as other kind of sensations. Food is evaluated by the consumers on the basis of various sensorial aspects: taste, olfaction, texture, color and cesia, among others. The experience of food consumption constitutes a typical case where synaesthetic associations are produced, in which it is difficult to separate or evaluate independently the different sensations, or where some of them influence the others. This proposal investigates the synaesthetic associations between color and taste sensations.

As a frame of reference, it is known that, in the same way as the color continuum has been ordered by means of three-dimensional systems, also taste sensations have been classified and ordered in a solid model. Hans Henning proposed a volume to represent the order and variation of taste sensations, which consists in a tetrahedron with the four primary tastes —sweet, salty, bitter, and sour— at the vertices. These four primary or elementary tastes have a correlate with four zones in the main organ for taste, the tongue. We distinguish here a connection between the way tastes are ordered and how the involved sensory organ works. A similar situation could be depicted with color order systems and the organs of vision, although it is somehow more complex. In the first stage, at the retina, the processing is made by a trichromatic system: the three kinds of cones sensitive to long, medium, and short wavelengths. And there are color order systems that represent this: they are organized by three primary colors —red, green, and blue—, such as the systems by Helmholtz, Maxwell, CIE 1931, Villalobos, Küppers, Gerritsen, and others. It is in a further stage where the visual processing is made on the basis of four elementary color sensations, and the theory of chromatic opponency is verified. And we can see this represented in systems such as those of Hering, Hesselgren, CIELAB, and the Natural Color System, among others.

Some of the questions that we can pose are: Which are the colors more strongly associated with each of the elementary tastes? And, symmetrically, which are the tastes more strongly associated to each of the elementary colors? Is it possible that associations between elementary tastes and elementary colors result from this? Or rather the correlations would be between elementary sensations of one continuum with intermediate sensations of the other one? Finally, if there is a definite correlate between elementary sensations of both continua —color and taste—, would the correlate still work for the intermediate sensations?

This paper will present the conceptual frame and some antecedents on this subject, as well as the methodology and results of an experimental survey made at the University of Buenos Aires, with the aim of answering some of the previous questions and showing how color synaesthesias work in the food environment.



## An fMRI study on the perception of the harmony of color and fragrance

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### Abstract

As we already know, our perception of color is not a simple sensation. Rather, we add on psychological elements such as emotion as part of our act of "seeing." This is what the cognition of color involves, and the integrated performance of this cognition is the result of the integrated union between the amygdala and the hypothalamus in our brain. Among various studies of visual brain areas and the functional specialization for different visual attributes, Semir Zeki and his group have discovered the areas for color and motion. They have also investigated the brain areas that were specifically engaged when subjects viewed paintings that they considered to be beautiful and found that the orbito-frontal cortex was engaged during the perception of beautiful paintings. Orbito-frontal cortex is well known to be engaged during the perception of rewarding stimuli.

The perceptions of beauty and harmony are both pleasant, agreeable and comfortable feelings, however, the brain areas which relate with harmony are not identified yet. The purpose of this study is to specify the areas that are committed when subjects consider color and fragrance are well-harmonized. This study follows the first author's paper concerning the harmony of color and fragrance which has been presented at AIC 2011 in Switzerland.

Healthy 20 subjects in 20- to 27-yr age participated in the study. The stimuli were 6 colors projected onto the screen; Red (255, 0, 0), Yellow (255, 255, 0), Green (0, 255, 0), Blue (0, 0, 255), Purple (255, 0, 255) and Gray (125,125,125) and the most preferred fragrance for each subject which he/she has selected among 120 various fragrances before an experiment started. Brain scanning was done in a 1.5T Magnetom Vision fMRI scanner (Siemens, Germany). Color stimuli were back-projected onto a screen viewed through an angled mirror. Subjects were presented 2 sets of 60 blocks (one session contained 6 colors with/without fragrance for 5 times). The activation of insular cortex indicated close relationship with amygdala and orbito-frontal cortex. The insular is integral to the experience of emotions and it plays an important role in the anticipation or expectancy of reward value. Consequently, it was suggested these areas seemed to be responsible for our esthetic judgments.

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## As pink as an orange blossom odor: a lebanese-french cross-cultural study

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### Abstract

Many cross-modal correspondences involving colors have been documented in non-synesthetes. Among these cross-modal associations, a small number of studies have attempted to investigate the relationship between odors and colors (see Gilbert et al., 1996; Schifferstein and Tanudjaja, 2004; Demattè et al., 2006). Consistent associations between specific colors and odors mainly related to food have been confirmed recently (Maric and Jacquot, 2012). It is well-known that culture-specific experiences with odors may influence different aspects of odor perception such as intensity, pleasantness or edibility. Differences in terms of color choice might therefore be expected depending upon the culture in which people grew up (Ayabe-Kanamura et al., 1998).

To further investigate the influence of experience on odor-color correspondences, the responses of 155 French and 96 Lebanese subjects to the same odorants were compared. In each country, untrained subjects were first presented with 16 food and flower natural odorants and asked to select among 24 colors the one that best matched each given olfactory stimulus. Secondly, they rated each odor according to four descriptors (intensity, familiarity, pleasantness and edibility).

Both populations matched olfactory stimuli with colors in a non-random manner. Indeed, significant color characterizations were found for all tested odors. For 12 odors, no significant differences were found between French and Lebanese subjects in all the matched colors. For 3 odors, no differences between the two populations were found in the mainly associated color. Somewhat unexpectedly, significant differences in colors association were only found for one odorant: orange blossom. Furthermore, a significant difference was found between the two populations in edibility ratings for this odor. This difference could therefore arise from cultural differences in the odor function.

Our results confirm the existence of robust odor-color correspondences among both populations and raise important questions about the representation of odors. This underlines the need for further studies to understand the mechanisms underlying these cross-modal correspondences and the influence of cultural background and experience on them.





## Prototyping experiences with food color

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### Abstract

The main goal of this article is to show that color is a fundamental value in gastronomy, as a perception index of the food consumed. At the same time, it proposes a methodology in the shape of a pedagogic exercise to demonstrate the perceptive experience of color. In this exercise, we implemented—as a tool for the elaboration of creative processes of innovation—an interactive learning model in which color theories and their design applications are introduced.

The course dynamics respond to the questions that are considered a key to understand the perceptive and cognitive processes that intervene in designing with colors. The questions are: Why the color of some food is not a like to people? Why do people—instantly—refuse elements with non-conventional colors? Which composites provide color to food?

Color is a determinant factor in the perception of food; it influences the choices of the consumer, who—to a good degree—chooses foodstuff depending in its appearance and texture. The natural color of food is a sign of its quality just as, according to some food experts, the artificial coloring gives added value to a product and is not harmful to your health. However, it is not always so and colored foods produce distrust when the time comes to eat them. Food and colors are associated with the environment, culture and diversity, and express themselves as codes. Changes in those codes are construed as changes in the environment; they give us information on their condition or their evolution in time. Likewise, psychologists, gastronomy experts and others devoted to the study of foodstuff, suggest that color tends to modify sensations such as taste and smell. Each person has a subjective appreciation of food gained in the course of her life, and it varies according to preferences, regions and customs. However, despite such appreciations, the criteria regarding color in food tends to unify a judgment about its condition, connected to appearance, ripening and production date.

The study of color implies not only knowledge of its essential and technical principles for use and application, but also involves the multiple answers given—consciously or unconsciously—by human beings to the stimuli received when color is used in daily life.

We have designed pedagogic dynamics that allow the students—after experimenting, experiencing, and confirming—to reinforce their knowledge of the effects of color, its interactions, applications, perception and meanings. Pedagogic innovation—through conceptual exercises and interactive learning—arouses curiosity and creativity among the students. That is the reason why we have created a practice focused on the emotive experiences, made evident through changes in the usual color of food.

Changing the color of food not only modifies its visual aspect, but also the smell, taste and memories it recalls, generating in the consumer pleasure or rejection, positive and/or negative emotions, that manifest themselves through salivation, body disposition and expressions of happiness, displeasure, repulsion or rejection among other emotions instantly and unconsciously expressed through gestures and body attitudes.





## Effects of personal background on residential wall color preference

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### Abstract

In a previous research<sup>1</sup>, I did a cross-cultural study regarding bedroom walls' color preference and concluded that there is not much color variety when Japanese people are choosing colors for their bedroom walls and they are all focused on white more so than others. In this research, through comparing different social and architectural contexts and experiments, we wish to clearly identify and investigate some of the factors influencing color preference. We have taken social environment as a primary focus and the influence of a person's residential, regional, educational and personal background have been examined.

In order to do this study, a questionnaire consisted of 14 questions based on a person's background, 2 drawings (one of a bedroom and another of the exterior of a few residential houses) and 24 color pencils were prepared. First, the respondents had to color out the drawings according to their preference, then, they were handed the questionnaire.

In total, 301 data were gathered from Iranian students living in Iran (94), Japanese students living in Japan (115), and foreign students living in Japan (92). The analysis was based on the comparison of the questionnaire and the number of the color varieties and the colors used in the drawings. One of the questions was the respondent's favorite color. The results showed that 98% of the respondents have used their favorite color in the drawings (both exterior and interior). Among other things observed was the bigger influence of education. The influence of education could be seen most in pre-school and elementary school ( $P < 0.01$ ). Furthermore, it was observed that the students who had parents with art backgrounds had more color varieties in the drawings rather than the ones with parents with no art background ( $P < 0.05$ ).



## Contextual associations affect warm and cold colours.

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### Abstract

**Introduction.** All people perceive colours as warm or cold, and this is one of the most common synaesthetic experiences involving visual and tactile senses. Recent researches tried to identify which colours appear warm and which cold, and proposed a number of models to determine the perceived temperature of colours given their CIELAB values. In those studies colours were observed on a neutral background (either white, grey or black), but it is well known that context can considerably modify how colours appear.

**Purpose.** Context can affect colour appearance in many ways, most often through contrast and assimilation induced by close or far coloured fields, or as a function of perceived illumination. In this work modifications in colour appearance were investigated by associating a colour sample to images which were expected to increase or decrease its warm/cold aspect.

**Methods.** A 6x6 cm square, filled by one of five colours (red, yellow, green, blue, and purple) was presented in the right side of a computer screen on a white-grey checkerboard background. A series of images was prepared with the aim of showing environmental situations characterised by warm, neutral, and cold 'objects', like flames, flowers, ice creams and so on; all the objects were then coloured with all the five colours (red, yellow, green, blue, and purple). A panel of 12 independent judges evaluated how much warm the images appeared in a 0-12 scale (0 very cold, 12 very warm). For each colour, three images evaluated as the warmest, three as the coldest, and three as the most neutral by the judges, were chosen so that, for each colour in the right of the screen, nine images with the same colour but different objects could appear in the left part. In the whole 45 colour-image combinations were used.

**Procedure.** A group of 43 participants with normal colour vision evaluated by cutting a segment in a visual scale (from maximum cold to maximum warm) each colour sample randomly presented at right of the screen after observing the image at its left.

**Results.** As expected the five colours resulted, in an analysis of variance, scaled in warmth and in significantly different steps according to the traditional order: red, yellow, green, purple, blue ( $F_{4,168} < 1.8E-39$ ); in this scale green and purple were not significantly differentiated (that is their temperature was judged the same). The effect of the associated images was also highly significant ( $F_{2,84} < 1.0E-12$ ) for almost all colours. For each colour, evaluations of warmth decrease significantly passing from colours associated to the "warm" images of the first group, to the "neutral" images of the second group, and lastly to the "cold" images of the third group, with two exceptions (out of 15 cases).

**Comments.** This research shows that the warm-cold aspect of a colour does not depend only on its colorimetric properties but also on the context in which is observed, which can significantly modify its perceived temperature. Worth of note is that the effect is not due to colour contrast or perceived illumination, but to the semantic characteristics of the associated images.

No preference for oral or poster presentation.



## Age effects on visual comfort as a function of lightness difference between text and background

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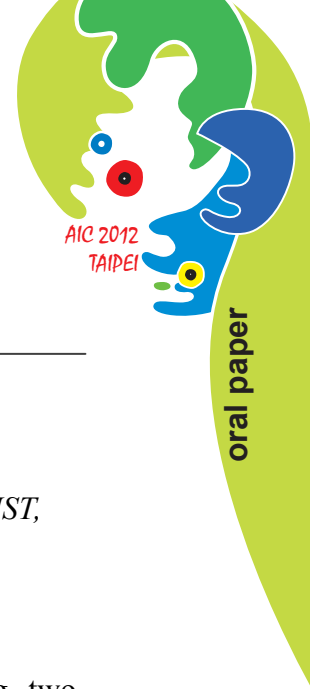
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### Abstract

Studies have reported that older people may benefit from using the Internet, such as keeping in touch with friends and family, new skills learning, personal financial management and online shopping. It was pointed out, however, that extensive reading on a display can cause visual discomfort, especially for older people. Luminance contrast for text and background on a display has been extensively studied regarding visual comfort. Despite the majority of papers showing the advantage of a high luminance contrast over a lower one, some studies reported that visual comfort was rated highest for the moderate luminance contrast, with poorer ratings for both extremely low and extremely high contrast levels. The potential impact of extremely high contrast ratios on visual comfort for different age groups is yet to be established.

To address the issue, a psychophysical experiment was performed using two groups of observers: young and older. The former consisted of 21 students (22-29 years) at the National Taiwan University of Science and Technology; the latter was comprised of 20 Taipei citizens, all at the age of over 60 years. The paired comparison method was used in this study, with 12 document layouts as the stimuli generated by all possible text-background combinations of 4 achromatic colors. The experiment was conducted in a darkened room (under 3 lux) using a display with maximum luminance of 551.77 cd/m<sup>2</sup> for either text or background. The experimental results show high correlation (R=0.90) between the two age groups, suggesting little difference between the young and older observers in terms of the effect of luminance contrast on visual comfort. The results were modeled as a function of the background lightness and the text-background lightness difference. The model shows that continuing to increase absolute lightness difference may result in a decline in visual comfort, which was found more significant on a dark background than on a light background.



## Color emotions of cubes and square patches

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### Abstract

Conventionally, color emotion studies are based on the experiments using two-dimensional square color patches although most of colored objects have three-dimensional shapes generating various color tones on the surface because of shadows and highlights. The aim of this study was to examine whether the color emotion of a 3D object is judged by one representative color or not by comparing the color emotions of 3D cubes and 2D color patches.

3D color cubes with three different colors (red, green, and blue) were generated using computer graphic tool and 16 colors were extracted from each cube. Each cube or square patch image was shown on the LCD monitor with gray background. 24 observers having normal color vision evaluated 4 color emotion scales, i.e., “warm-cool”, “heavy-light”, “active-passive”, and “soft-hard” using 7-step categorical judgment method in the dark room.

The data analysis results show that all four color emotions of 3D cube mainly come from most chromatic color area on the surface. It implies that the previous color emotion research results using square color patches can be applied to 3D object’s color design at least as long as both 3D and 2D objects have similar shape emotion.

The experimental data of square patch experiment found that, except warm-color emotion scale showing hue dependency only, other emotions scales show strong linear CIELAB L\* and C\* dependency. As CIELAB L\* and C\* increases together, colors tend to be perceived as lighter, more active and softer. Especially, heavy-light emotion scale shows little hue dependency.

Finally, the four color emotions models were evaluated developed by Sato, Ou, Xincheng and Marcel. Except active-passive scale, where all the models show poor performance, most of them showed good linearity but shifted emotion toward heavy and hard direction.

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## Intensity independent TI D-to-Z[ \ colour camera calibration

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### Abstract

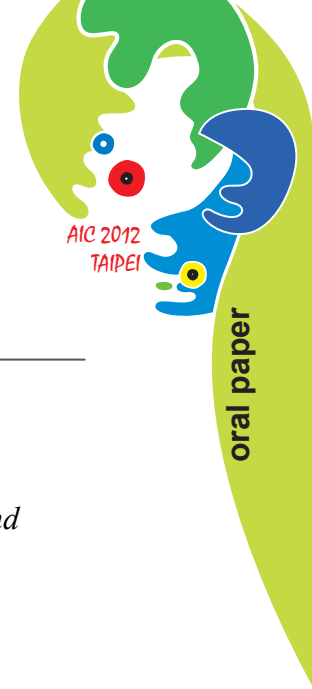
In order for a digital colour camera to represent the colours in the environment accurately it is necessary to calibrate the camera RGB outputs in terms of a colorimetric space such as CIE XYZ. Assuming for the moment that the camera response is a linear function of scene luminance, the main step in the calibration is to determine a 3-by-3 linear transformation matrix,  $T$ , mapping data from (linear) RGB to XYZ. Determining  $T$  is usually done by photographing a calibrated target such as a colour checker and then performing a least-squares regression on the difference between the camera's RGB digital counts obtained from each colour checker patch and their corresponding true XYZ values.

One difficulty with this method is that it is hard to create an environment in which the lighting is completely uniform. While we may assume that the *relative* spectral power distribution of the illuminant is constant, its irradiance is likely to vary across the colour checker, thereby affecting the RGB digital counts. If the amount of variation in the irradiance is unknown, then the "true" XYZ values will not correctly model the scene, and so the colour correction matrix  $T$  computed from them will also be incorrect. One way to account for illumination variation is to measure the irradiance at each patch, but this extra step can be quite time consuming. It would certainly be preferable to measure the illuminant spectrum at only one location and have a method for deriving matrix  $T$  that works even when the irradiance is non-uniform. Just such an illuminant-independent method is proposed here.

A difference in irradiance on a patch results in a scaling of the associated RGB digital counts. In other words, treating RGB as a vector, its length changes, but not its direction. Unlike the traditional least-squares method (which takes into account both the direction and magnitude of RGB vectors, and thus is affected by any irradiance-induced scaling) the proposed method seeks the 3-by-3 linear transform that minimizes the sum of angles between transformed RGBs and XYZs, thus aligning the vectors from RGB space to those in XYZ space without regard to their magnitude. As a result, the effect of irradiance is eliminated from the minimization. Applying this method for camera calibration eliminates the need to ensure that the illuminant is constant across the scene. In other words, the final colour correction matrix will be the same whether or not there is any variation in the irradiance.

In conclusion, for a digital colour camera to accurately reproduce the colours in the

environment it must be calibrated to map raw camera RGB outputs to colorimetric XYZ. The proposed method is a nonlinear optimization based on minimizing the angles between colour vectors, and has been shown to be advantageous when the lighting environment is non-uniform. The final paper will include results demonstrating the effectiveness of the method in calibrating two real cameras.



## Gamut comparison index: a metric for comparing colour gamuts

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### Abstract

It is often necessary to be able to compare two or more colour gamuts, in order to determine how similar they are. For example, if a colour image is to be re-targeted to a different medium, we may wish to know whether the second medium has a sufficiently similar gamut to make an acceptable reproduction a possibility.

The gamut volume alone enables a comparison of the size of the gamut, but not whether the gamuts intersect sufficiently to meet the reproduction aims. This can be achieved by visual comparison of the two gamut volumes in a pseudo-3D rendering, but it would be useful to have a single-number value which enables this comparison to be computed from the gamut boundary description of the two gamuts.

A new metric is proposed to quantify the similarity between gamuts. The Gamut Index is computed as  $V_i^2 / V_1 V_2$ , where  $V_i$  is the volume of the gamut intersection in the CIELAB colour space, and  $V_1$  and  $V_2$  are the volumes of the gamuts being compared.

The resulting index has a value ranging from 1, for two gamuts that have the same volume and intersect perfectly, to zero for two gamuts that do not intersect anywhere.

A number of test cases for the index were computed, including comparison of a reference colour gamut such as those defined in ISO 12640-3 with the gamut achieved by an encoding, transform, or actual device. The results indicate that the gamut index gave a consistent prediction of how well the two gamuts compared. Use of the resulting Gamut Index value would enable users to select the transform or device that best matched the reproduction aim.

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## Investigation of colour and appearance for human skin

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### **Background.**

With greatly simulated interests in colour of human skin by the increased need in its application within multidisciplinary teams, there is strongly desire for a comprehensive knowledge of the skin shades that represent individuals, an understanding of how skin colour varies and how people perceive these differences in a wide range of viewing conditions.

### **Objectives.**

The aim of this study was to establish a skin colour database under controlled viewing conditions and objectively predict skin colour appearance, produce skin colour gamut and quantifying skin colour variation between different ethnic groups, genders and body areas.

### **Method.**

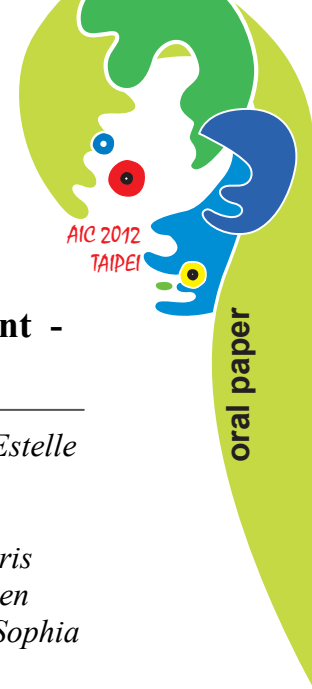
Ethical approval was obtained from the University of Sheffield UREC to carry out this study on volunteers. A target was set to obtain direct colour measurements for 100 subjects from each of six ethnic groups. Measurements were undertaken using a CM 2600d spectrophotometer under standard D65 illuminant. Both CIE XYZ tristimulus values and spectral reflectance were measured for each subject from 9 different body positions on the face and arms. CIECAM02 colour appearance model was used to predict skin colour appearance and their 3D skin colour gamut.

### **Results.**

To date we have collected data for over 400 subjects in three different ethnics groups. Firstly, skin colour variation for different body points on the same subjects were investigated and there was a clear trend in that facial colour tended to be more reddish than arm colour and this was indicated by a significant shift in hue and chroma. Secondly, skin colour variations between different ethnics groups were also analysed. Results demonstrated that there was a largest variation for skin colour related to the hue, whilst chroma was considered the most consistent attribute across the skin samples measured. There was a clear trend that Chinese skin has a darker, less saturated and significantly more yellowish compared with Caucasian skin. Furthermore, it was also found that compared to other ethnic groups, Caucasians has the largest variations in skin tones.

### **Conclusion.**

A skin colour database for 3 ethnics groups was largely achieved by direct colour measurement. For each ethnics group, skin colour appearances were predicted and their skin colour gamuts were developed. The skin colour variations were investigated based on ethnic group difference, gender difference and body area difference. Further data collection is required to establish the investigate skin colour and appearance for other ethnic groups.



## Understanding the colour of polymers in their lighting environment - application to color-changing materials in interior design

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### Abstract

This paper aims at understanding the origin of colour in some materials used for interior design, and the interactions between the materials and some sources of light used in man-made environments. Beyond the scientific scope, the purpose is to enhance sensorial experience in inner spaces through the development of a material, used for wall or floor covering, which does not rely on any source of power and can interact with its lighting environment to convey an impression of changing its colour.

Mineral fillers (calcite, alumina, kaolinite, black iron oxide) with different shapes, sizes and refractive properties are dispersed in two types of calendered transparent polymers: low-density polyethylene and PVC. The polymer films are then embossed with different pattern and roughness. The influences of the volume and the surface of the materials are taken separately into account throughout the colorimetric analysis.

On the one hand, Yxy-1931 colorimetry (Minolta CR-201b Chromameter) shows that the colour depends on the type and concentration of fillers, their size, and the type of polymer when the volumetric concentration of filler remains the same. Further investigation with the optical microscope (Leica DRMx) and its calibrated CCD camera are lead to locally measure the color through a particle and understand the influence of the interface between the filler and the polymer.

On the other hand,  $L^*a^*b^*$  measurements are done in front-scattered light on different embossed materials with a gonioscopic device built at MINES ParisTech and equipped with a spectroradiometer (Ruby Stil S.A. France). The angular range goes from  $0^\circ$  to  $70^\circ$  for the sensor and the light sources. The influence of the illuminant is measured with a halogen light source (100W, 3200K) and a high-power white LED (5500K). Most variations in colour due to roughness are related to the change in luminance  $L^*$ : very small changes are noticed in  $a^*$  and  $b^*$ . These are correlated with topographical data measured by a chromatic confocal scanning system (Stil S.A.).

Finally, the perception is assessed in a human-scaled environment with different positions of the two illuminants in a  $2m \times 2m \times 2.4m$  box. It is built with achromatic white extruded PVC sheets, lights up the samples with direct and indirect beams, and the results are provided both qualitatively by the students and quantitatively by a camera. The samples can be rotated to change the direction of the specular reflection.

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15:40 RM

## The influence of background on colour harmony

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### Abstract

Many researchers have tried to discover universal laws of colour harmony, as if by analogy with music there were some underlying relationships between the physical attributes of colour that would result in a perceptual affinity. For example, the ratio of the dominant wavelengths of two colours might determine the harmonic relationship of their perceived hues. This has resulted in many schemes of ordering two or three or more colours, usually by their hue relationships but sometimes also by lightness and chroma, to produce colour harmony. The 12-hue colour star devised by Itten (1961) is a good example, by selecting dyads, triads, etc. from a circular hue order. Similar schemes have been applied to the Munsell, Ostwald, NCS, Coloroid and other colour spaces.

Yet experimental studies of colour harmony with observers almost invariably present the colour samples against a neutral background, typically Munsell value 5. This avoids problems associated with simultaneous contrast, causing chromatic induction, where the colour immediately surrounding a sample causes it to be perceived as tinged with the opponent of the surround. Thus a grey sample surrounded by blue is perceived as yellowish and vice versa (Luo et al, 1995). In their thoughtful discussion of colour harmony, Sivik and Hård (1994) observed: "Moreover, a colour cannot exist alone. When a single colour surface is presented it must have a surround, which also has a colour; and it is, thus, this pair of colours that is seen and experienced, even if one consciously tries to perceive only one of them."

In the study of colour harmony the influence of the background has rarely been considered. This is surprising because the background, extended to fill the visual field, determines the state of adaptation of the human visual system, and therefore anchors visual perception. All colours are judged against the average background, especially in terms of lightness. Changing the background changes the way colours are judged, and therefore changes the perceived harmony between colours in the scene. Gurura et al (2004) showed that changing the background could result in a formerly harmonious colour combination being judged as disharmonious.

This paper will examine the influence of background on colour harmony, and will present the first results of experiments from a remarkable new piece of laboratory equipment which immerses the observer and enables his or her visual field to be completely controlled.



## Readability of colored text on a colored background under led lighting and fluorescent lighting

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### Abstract

Recently, LED lighting is becoming to be used for general lighting such as store lighting. In order to save electricity, especially after the Tohoku Earthquake, many convenience stores changed the store lighting from fluorescent lamps to white LEDs.

Incidentally, according to the change of Japanese Pharmaceutical Affairs Law, some drugs became to be sold at convenience stores recently. For example, a consumer might have to read the brand name and instruction of the drug written on package under LED illumination. On these packages, texts and backgrounds with various colors are printed on surface. The replacement of the store lighting from fluorescent lamp to white LED would cause the change of colors of the text on the package as well as the colors of the package surface, because of the different spectral power distribution of those two sources. Accordingly, readability of the text might be degraded in some cases, or improved in other cases.

Therefore, this study aims to clarify whether the difference of light source (white LED and fluorescent lamp), affects the readability of various colored text on various colored background. We also investigated whether its readability of color characters was different by aging of readers.

In result of preliminary experiment of readability under fluorescent light, it varied widely among color combinations. In first experiment, whether the effect of color combination differs between the LED lighting and fluorescent lighting conditions was investigated. Test stimuli with 20 color combinations were compared the readability by elderly observers. Rating score of each stimulus under the two conditions generally agreed with each other. However, statistically significant difference was found for six color combinations, showing better performance under the LED for all of them. In second experiment, whether the above effects of color combination and light source differ between young and elderly observers was investigated. Test stimuli with 9 color combinations were compared the readability.

Results of the young and elderly observers generally showed similar tendency. Noticeable difference is that results of the young showed strong correlation with luminance contrast except the color combination of blue and black, while the correlation with luminance contrast was weak in results of the elderly, indicating that the contrast calculated using  $V(\lambda)$  is not a main factor for readability for elderly observers.

It is indicated that to design texts on a package with a good readability, not only color combination of text and background, but also spectral power distribution of light source in the space and age effect should be taken into consideration.



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16:20 RM

## Psychological evaluation of the interior color scheme among ages

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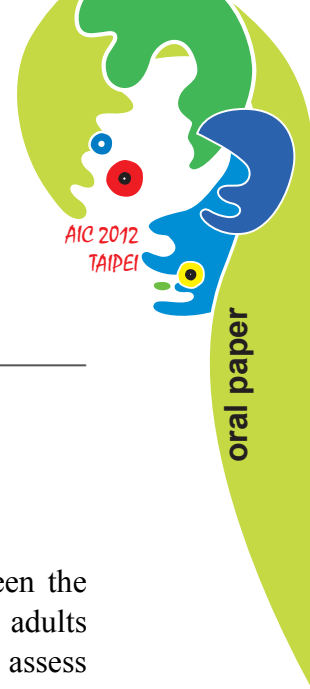
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### Abstract

The purpose of this study is to analyze the impression evaluation of different patterns of interior colors, which changed in door and floor colors, and develop an interior evaluation map based on the results. The study shows that the effect of evaluation differs among ages. We conducted an impression evaluation experiment on 288 subjects using 15 adjectives by the Semantic Differential method. Computer graphics of several interior color patterns were used for this purpose. The interior colors were based on actual colors used in interior space, and we produced

31 interior color patterns using computer graphics. According to cluster analysis based on these impression evaluation scores, 31 interior color patterns were classified into six clusters as follows: (a) a pattern consisting of an all-white floor [white floor]; (b) a pattern having a brown color scheme or having the same brightness as that of a two-color scheme using brown [brown]; (c) a pattern that has a strong shade of a brown or one that has a combination of white and a soft shade of brown [brown contrast]; (d) a pattern using a black color scheme [black]; (e) a pattern using a dark-brown color scheme [dark brown]; and (f) a pattern that contains a unique color scheme [unique]. The white floor, brown, brown contrast groups were assigned bright and light spacious impressions. The black and dark brown groups were assigned deep and dark impressions. Furthermore, using factor analysis, for these patterns, we evaluated the following factors that affected the impression of each interior color pattern: (a) evaluation; (b) light and brightness; and (c) familiarity. The results of impression evaluation indicated not only that there are differences in impression evaluation among ages but also that the effect of evaluation varies more widely among different age groups compared with other factors. Moreover, this was particularly observed with black door and white floor combinations, and black door and black floor combinations.



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16:40 RM

## Prediction of a taste from color and its practical application

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### Abstract

The purpose of this study is to investigate and quantify the relationship between the attributes of color and the perceived quality of taste. A survey with 100 Korean adults was conducted and 120 color patches were presented. Each subjects was asked to assess perceived taste in terms of sweet, sour, bitter, salty, and spicy aspects of taste while he or she was viewing the given color patch. Based on the subjects' ratings, a multiple regression analysis was performed in order to derive formulae by taking the CIE 1976 L\*a\*b\* values of a color as independent variables (see Table 1). It was revealed that in perceiving bitterness ( $R^2= 0.24$ ) followed by spicy taste ( $R^2= 0.23$ ) by viewing color is more predictable than other tastes. Moreover, as shown in Table 1, the contribution of color attributes to different taste dimensions is a lot varying.

Taste dimension	Formulae to predict the intensity of taste by CIE 1976 L*a*b* values of a color, $C = (a^2 + b^2)^{1/2}$ (%)	R <sup>2</sup>	Sig.
Sweetness	$-1.07 + 0.51*L + 0.29*a + 0.19*C$	.15	.00**
Sourness	$-7.01 + 0.42*L + 0.36*C$	.14	.00**
Bitterness	$92.53 - 0.75*L - 0.59*C + 0.34*b$	.24	.00**
Salty taste	$28.67 - 0.09*L - 0.07*C + 0.06*a$	.01	.00**
Spicy taste	$13.53 + 0.37*a + 0.31*C - 0.18*L$	.23	.00**

Table 1. Formulae derived from the survey ratings.

As an extension to a practical application, the formulae were utilized, firstly, in order to predict the taste based on the characteristics of color of the food and secondly to distinguish the colors according to the profile of taste. In this foregoing, a test with three types of food—chocolate, capsule coffee, red pepper paste—was carried out (N= 100), and each type of food had 5 to 7 variations of color. The formulae were applied to rank the colors of each food in terms of sweetness (chocolate and red pepper paste), bitterness (chocolate and coffee), and spicy taste (red pepper paste). The result shows that the formulae are generally valid when the food or food package is diverged through color variation rather than straightforwardly to predict the taste intensity of the food by viewing a color.





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## Visual impression of a color group characterized by a colored light source and its applicability to color design

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### Abstract

Color is important for design practices in any built-environments and products. A systematic method producing harmonious color arrangement is worth investigating both in a scientific and practical point of view. In our previous study (Ishida and Mori, 2011), we showed that a color group characterized by a colored light appeared to be harmonious. In this study, we extended our previous study and examined applicability of the method to color design. We assessed a sense of visual harmony, preference, activity, potency and warmth of the color arrangements characterized by colored lights. The applicability of the color groups to color design of an interior space was examined using computer graphic images.

In experiment 1, an arrangement of color chips was illuminated by a colored light source. A white screen board with apertures arranged in a grid placed between a subject and the color arrangement. The subject viewed the color arrangement through a small viewing aperture. Using this setting, the subject viewed the color chips as if they were placed on the white screen under the white light. That is, only colors under the colored light were presented on the white background. The sizes of color arrangements were 3x3 and 4x4. We prepared 10 color arrangements for each of two sizes by selecting colors from a set of color chips. We set 16 lighting conditions; 5 hues (red, yellow, green, blue and purple) and 3 saturations (low, middle and high). Since color chips were chosen randomly, the color arrangements under the white light condition expected not to give any distinct visual impressions. Our question was whether the colored light gave some common visual impression to the color arrangement. Ten subjects from Kyoto University participated in the experiment.

The result clearly showed that the color arrangements under the colored light were evaluated more harmonious and preferable than those under the white light condition. It was also found that the colored light gave unique impressions to the color arrangement. A sense of activity was enhanced by the red light condition. The warm and cool impressions were produced by the red and blue lights respectively. The characterization by the colored light added softer impression to the color arrangement.

In experiment 2, we tested if the visual impressions obtained from the color arrangements could be reproduced when we applied those colors to actual scenes. A computer graphics of a single room was created and several colors chosen from the color groups characterized by the colored light were applied to some pieces of furniture in the room. The senses of warmth and activity were reproduced in the room images. However, the senses of harmony, preference and potency were modified when the colors were applied to the room images, suggesting an interaction between colors and actual objects. The applicability of the method will be discussed.

## Spectral-based optimal daltonization model for dichromatic color vision

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### Abstract

Most of color blind simulators have followed the Brettel-Vienot-Mollon's model. The model is widely accepted, but it didn't deal with the spectral analysis. In the previous paper (CIC19, Nov.2011, San Jose), the author proposed a spectral-based dichromatic vision model based on the "Matrix-R" theory extended to the 2-D dichromatic version. The new model clarified what regions in input spectra are visible or invisible to the dichromats and extracted the lost spectra as a spectral difference between the trichromatic *fundamental*  $C_{norm}^*$  and the dichromatic *fundamental*  $C_{dich}^*$ . The lost spectra interpreted the spectral background of color blindness and are useful for daltonization. However, the first version had a drawback of using expensive spectral image inputs. This paper presents the improved 2<sup>nd</sup> version. It makes use of sRGB image instead of spectral image and proposes an optimal daltonization method for maximizing the dichromatic *visibility* for confusing colors. The new model is designed as follows

- [1] The trichromatic *fundamental*  $C_{norm}^*$  (visible spectra to normals) is recovered from a calibrated *sRGB* image by applying the pseudo-inverse operator  $P_{inv}$  as

$$C_{norm}^* = P_{inv} (M_{sRGB \rightarrow XYZ}) sRGB, \text{ where, } P_{inv} = A(A^t A)^{-1}, \quad (1)$$

$A = CIE \text{ color matching matrix, } M_{sRGB \rightarrow XYZ} = sRGB \text{ to XYZ matrix}$

- [2] The dichromatic *fundamental*  $C_{dich}^*$  (visible spectra to dichromats) is given by applying the extended dichromatic *matrix-R*  $R_{dich}$  to the trichromatic *fundamental*  $C_{norm}^*$

$$C_{dich}^* = R_{dich} C_{norm}^*, \quad R_{dich} = A_{dich} (A_{dich}^t A_{dich})^{-1} A_{dich}^t$$

$$A_{dich} = [m(\lambda), s(\lambda)]: \text{protan, } A_{dich} = [l(\lambda), s(\lambda)]: \text{deutan, } A_{dich} = [l(\lambda), m(\lambda)]: \text{tritan} \quad (2)$$

$l(\lambda), m(\lambda), s(\lambda) = L, M, S \text{ cone spectral sensitivity functions}$

- [3] The lost spectra is given by taking the difference between Eq. (1) and Eq. (2) as

$$\Delta C_{dich}^* = C_{norm}^* - C_{dich}^* = (R_{norm} - R_{dich}) C_{norm}^*, \quad R_{norm} = A(A^t A)^{-1} A^t \quad (3)$$

- [4] The lost spectra are shifted by a wavelength  $\lambda_{shift}$  to make the best matching with the dichromatic cone sensitivities. For example, the best fit shift wavelength  $\lambda_{opt}$  is determined by maximizing the spectral matching between the shifted lost spectra and the each dichromatic cone sensitivities for protan, deutan and tritan. The spectral matching is measured by the function  $\Psi(\lambda_{shift})$  defined as inner product  $(\bullet)$ .

$$\Psi(\lambda_{opt}) = \max_{\lambda_{shift}} \{ \Psi(\lambda_{shift}) \} \text{ for } \lambda_{shift} = 380 \sim 730 \text{ nm, } \Psi(\lambda_{shift}) = \Delta C_{dich}^* (\lambda - \lambda_{shift}) \bullet \{ \mathbf{u}(\lambda) + \mathbf{v}(\lambda) \}$$

$\text{where, } \{ \mathbf{u} = \mathbf{m}, \mathbf{v} = \mathbf{s} \} \text{ for protan, } \{ \mathbf{u} = \mathbf{l}, \mathbf{v} = \mathbf{s} \} \text{ for deutan, } \{ \mathbf{u} = \mathbf{l}, \mathbf{v} = \mathbf{m} \} \text{ for tri tan} \quad (4)$

Here,  $\Delta C_{dich}^* (\lambda - \lambda_{shift})$  denotes the lost spectra after "shift-rotate-left" by  $\lambda_{shift}$ .

- [5] Finally the daltonized spectra  $C_{dalt}^*$  is created by adding the optimal shifted lost spectra  $\Delta C_{dich}^* (\lambda - \lambda_{opt})$  to the normal *fundamental*  $C_{norm}^*$  and displayed as *sRGB*<sub>dalt</sub>.

$$C_{dalt}^* = C_{norm}^* + \Delta C_{dich}^* (\lambda - \lambda_{opt}) \text{ and } sRGB_{dalt} = (M_{sRGB \rightarrow XYZ})^{-1} A^t C_{dalt}^* \quad (5)$$

The simulated colors by the proposed model resulted in much the same as Brettel's model and the proposed daltonization method dramatically improved the dichromatic visibility in comparison with the most popular blind simulator "Vischeck".



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15:60 RM

## Early fungus infection detection in lemon fruits by means of spectral and colour analysis

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### Abstract

Citrus are one of the major plants cultivated in the world. They are grown in more than 100 countries including the main producers such as China, Brazil, the USA, Spain, Mexico, Italy and Argentina. With respect to lemon, Argentina is the first producer (approx. 1.4 Mt). This number shows the economic importance of this activity.

Current commercial systems classify the fruit based on quality parameters. The main characteristic to attribute the quality of fresh fruits is the appearance, characterized by combination of size, shape, colour and absence of defects. The defects could be caused by biological, physiological or environmental factors in addition to mechanical damage. These defects could be originated in the cultivar or in the post harvest management. Among the later, fungi of the genera *Penicillium* are responsible for substantial losses in citrus fruit during post harvest processes. Due to citrus fruit infected with that fungus are not marketable, it is imperative to detect the problem as early as possible, before it becomes visible, to allow the producer to take the corrective actions.

The objectives of this research were (1) to acquire spectral reflectance characteristics of fungus attacked citrus peel conditions, (2) to identify the significant wavelengths that have the maximum discriminatory capability, and (3) to derive a methodology using these wavelengths that could allow the early detection of the infection.

In order to reach those objectives we analyse the infection process by means of spectral reflectance techniques, to detect the infection between 24 and 48 hours after the inoculation.

Measurements of spectral reflectance and colour characteristics of healthy and inoculated lemons were taken with a PR715 Photo Research spectroradiometer, in the range of 380-1050 nm under diffuse lighting conditions, in four experiments with controlled conditions. In all the four series measurements were taken periodically on the inoculation point and on the opposite side of the fruit with intervals of 12 hours, over samples with different size and ripening.

From the results, a wavelength (676 nm) was identified as a carrier of useful information about the infection process, particularly the temporal variation of the spectral reflectance at 676 nm. The increased gradient of the spectral reflectance value at 676 nm compared with the gradient corresponding to the healthy portion of the fruit could be an indicator of the presence of the infection.

Similar analysis was done taken into account the colour measurements. Results obtained suggest that consideration and analysis of "colour-change speed" (i.e. the colour displacement within a suitable colour space divided by the time it takes) seems to be a very efficient tool to diagnose the infection before it becomes visible.



## Intelligent spectral design for 3G and 4G light sources

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### Abstract

The energy-saving light sources of the first two decades of the 21<sup>st</sup> century (CFLs, LEDs, etc.) may be thought of as the basis of 3G lighting, while 4G light sources can be looked upon as those that are still beyond our current technological horizon.

While energy saving is an important property of all such light sources, there are also instances when superior colour rendering performance is a prime requirement (e.g. lighting for merchandising, lighting of artworks, lighting for colour processes, etc.). The aim of our work has been the creation of computational tools for the optimum design of the spectrum for such a light source, to achieve an effective combination of both colour rendering and energy efficiency.

Our approach excludes the physical processes that are needed for the conversion of input energy (most often electrical) into radiant energy. Our focus is rather on the distribution of energy within the radiant spectrum since this determines both the luminous efficacy of the radiation and its colour rendering properties.

The optimization tool is a Matlab-based implementation of the population-based differential evolution (DE) algorithm where a population of possible solutions is evaluated using a fitness function, and only those solutions having better scores are further optimised and others are discarded from the optimization. The optimum solution is determined after having performed  $G$  cycles of the evaluations and optimizations.

In this work, DE was adopted for the optimization of mixed narrow-band white-light spectra. A solution is the spectrum of the light produced by a mixture of narrow bands, and only those spectra having better colour-rendering characteristics and higher radiant luminous efficacy are kept for further optimization. The best solution in cycle  $G$  is accepted as the best white-light spectrum.

The fitness functions shown in equations (1) and (2) have been developed for optimizations based respectively on the CIE colour rendering index  $R_a$ , and the NIST color quality scale  $Q_a$ .

$$f_{fit(CRI)} = aR_a + bR_b + cR_c + d\eta_{rad} + eR_{min} \quad (1)$$

$$f_{fit(CQS)} = aQ_a + b\eta_{rad} + cQ_{min} \quad (2)$$

The coefficients  $a$ ,  $b$ ,  $c$ ,  $d$ ,  $e$  are user-selected weighting factors for the various terms considered important in the optimum source spectrum. In equation (1)  $R_a$  is the colour rendering index, and  $R_{min}$ ,  $R_b$  and  $R_c$  are other terms derived from amendments to the CRI calculation procedure. In equation (2)  $Q_a$  is the colour quality scale value, and  $Q_{min}$  is a term derived from a variation to the standard CQS calculation. In both equations,  $\eta_{rad}$  is the luminous efficacy of the radiation.

We have explored the use of these optimization techniques to derive optimized mixtures of LEDs, as well as optimized source spectra based on mathematical spectrum shapes (as signposts to possible future developments in light-source technology).

These developments are likely to have an impact in illumination engineering generally, and in conservation lighting of artworks in particular.



AIC 2012  
TAIPEI

oral paper

9/27 Vwgday  
16:40 RM

## The modified uniform oil colour scale (O WQEU)

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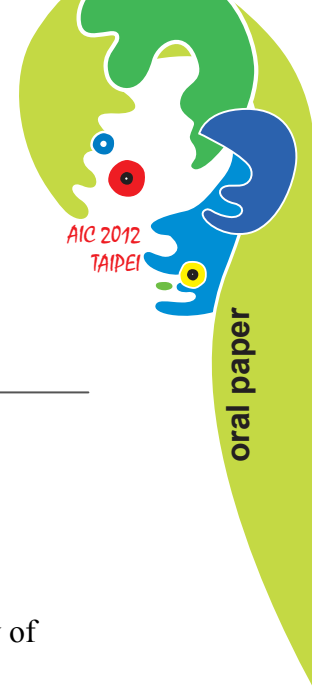
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### Abstract

Spain is the world leader producer of virgin olive oils. Current quality control of virgin olive oils must include simple and accurate colour specification methods. We propose the Modified Uniform Oil Colour Scale (MUOCS) as a simplified method for colour specification of virgin olive oils, based on a set of 60 points (MUOCS standards) which are spread in the DIN99d colour space following a regular rhombohedral lattice like the one employed by the Uniform Colour Scales of the Optical Society of America. MUOCS standards try to sample the colour gamut provided by a wide set of 1700 virgin-olive-oil samples collected during 4 different harvests. The final MUOCS specification of a virgin-olive-oil sample is a 3-numbers code (Lightness-Green-Yellow) computed from the lowest DIN99d colour-difference between the oil sample and each one of the 60 MUOCS standards. Internal spectral transmittances using 5-mm pathlength cells, CIE D65 standard illuminant, and CIE 1964 colorimetric standard observer are assumed in the MUOCS method. The current method for colour specification of virgin olive oils is the Bromthymol Blue (BTB) scale (Grasas Aceites 37, 282-286, 1986), which is based also in 60 standard colours. For the 1700 virgin-olive-oil samples, the average colour difference to the closest MUOCS and BTB standards were 2.86 and 8.17 CIELAB units, respectively, which indicates a relevant improvement of the MUOCS method with respect to BTB. Looking for an easier use of the MUOCS method two approaches are presented here: 1) A low-cost (<60 Euros) portable electronic device designed by us, which is calibrated from BTB standards and provides colour specification of a virgin olive oil both in the BTB and MUOCS scales. For a reduced set of 37 commercial virgin-olive-oil samples the MUOCS code provided by this device was correct in 92% of the cases. 2) Linear regression models allowing computations of each one of the three components in the MUOCS code from measured CIELAB coordinates of a virgin-olive-oil sample. For a random set of 10000 theoretical samples in the gamut of the 1700 virgin-olive-oil samples, these models correctly classified MUOCS Lightness, Green, and Yellow in 98.6%, 88.3% and 100% of the cases, respectively, assuming a tolerance of  $\pm 1$  step in each one of the components.





## A legibility study of the layouts and color combinations of e-Book titles

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### Abstract

In order to find out the impacts of layout formats and color styles on the legibility of e-book titles, this study investigated arrangements of horizontal and vertical text orientation, fonts, and various color styles of e-book titles and their backgrounds by eye-tracking method. It was explored whether layout formats and color styles of e-book titles have an effect on the physical activities of the eyes: on reading time, fixation duration, saccadic amplitude, and blink frequency. First, a pilot study was conducted to determine the procedure and the stimuli to be employed in the formal experiment. Here it was found that horizontal or vertical directions of the text have no significant effect on text legibility. The final design of the study included (a) the presentation of the title in two types of fonts and (b) thirty sets of color combinations. The experiment was conducted in a controlled laboratory setting: an eye tracker precisely recorded eye fixation and fixation duration. Color combinations of the virtual titles and backgrounds were chosen from four basic colors (red, blue, green, and yellow) based on the NCS system, and three neutral ones (black, grey, and white). The study involved a five-point Likert Scale survey presenting twenty-four types of layout to 16 art editors and text editing experts to find out two most frequently used layout types. Results showed that color combinations of words and their backgrounds have significant effects on text legibility while font types and text directions have not. More legible color combinations are white text on black background, white on blue, red on grey and green text on white background. Less legible combinations are green text on grey background, grey text on green, blue text on grey and yellow text on white background.

9/25 Tuesday  
14:40 PM



## Effects of colour and chromatic light on depth perception

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### Abstract

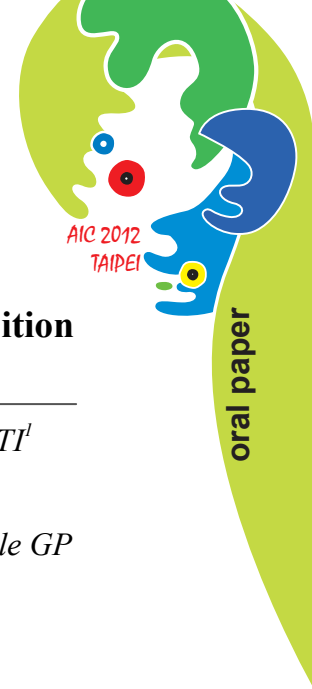
Understanding the perception of space and the interaction between surface colors, illumination chromaticity and space enables their effective use in interior architecture, lighting and stage design. Space perception is the ability to estimate the three-dimensional layout of our environment, the arrangement of individual objects and their location and size. In that context, many studies focus on the perception of distance as the central problem of space perception (Boff et al, 1986). In this distance estimation, the human visual system uses a number of physical attributes, or cues, from the environment (Sekuler and Blake, 1994; Michel, 1996).

Among the monocular cues, color is one of the most debated. While the effect of brightness and saturation on depth perception, both absolute and with relation to the background, is studied extensively, studies of the effect of hue have been limited and with contradictory results. The study presented in this paper attempts to bridge this gap by studying the effect of chromaticity and chromaticity combinations on depth perception.

Using a 1/1 scale interior space, the apparent displacement of two equal objects due to object chromaticity and background chromaticity using monocular viewing at a distance of 10 meters was measured (Figure 1). To minimize measurement error, a forced choice paired comparison, followed by an estimation of a psychometric curve was used to measure the baseline (neutral object color, neutral background chromaticity) and the effect of chromaticity and chromaticity combinations (17 pairs in total) (Figure 2). The brightness of all the stimuli was matched and kept constant.

Results from 21 participants show a surprising, but consistent inter-observer variance in the depth perception in the right and left visual field. A repeatable, participant dependent offset of up to 25 centimeters for two neutral chromaticity objects on a neutral background was demonstrated. For some observers, the object in the right visual field appeared closer, and for some in the left. After correcting for the baseline differences, a significant effect of both color and color combination on depth perception was found. Cooler objects were generally found to be perceived as further away than warmer ones, as were the achromatic objects. The effect was increased by increasing the chromaticity difference with the background.

This effect size, however, was smaller than the inter-observer variance in the baseline, which shows a limited utility for chromaticity as a tool for depth perception manipulation. The result also shows that using the lighting chromaticity, the atmosphere in an environment can be manipulated without strongly influencing the space perception. Even more, the methodology developed can be used in future psychophysical studies that expect a large baseline variation between observers.



## Color matching for colour constancy and inconstancy in the transition between foveal vision and extra-macular vision

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### Abstract

The daily experience of colour vision induces us to ignore the filtering due to the macula lutea and to consider the foveal and the extra-macular visions as equal. Rarely colours in foveal vision are different from those seen in extra-macular vision and this happens in presence of narrow-band spectral lights. This phenomenon is possible in the colour matching by 2 degree bipartite field, where, once obtained a matching for foveal vision, the observer moves the attention point and the bipartite field is seen by extra-macular retina. Since the main difference between the two kinds of vision is produced by the filtering of the macula lutea, the equality of the colours perceived in these two visual situation is considered as a colour-constancy phenomenon and the difference of the perceived colours as a colour- inconstancy phenomenon.

This work proceeds in two steps: 1) Check the existence of colour matching made by wide band lights true for foveal and extra macular vision and for different individual observers; 2) Empirical estimation of the minimum band-width of spectral lights required to have colour matching for foveal and extra macular vision and for different individual observers.

The observers involved in this experiment are three, with normal trichromatic vision, but different sex, age and colour-matching functions.

Cross-media colour matching made by mixture of wide band lights has shown that equal colour matching holds true for all these observers in foveal vision and extra-macular vision. The lights of the bipartite field are produced by a CRT monitor in one side, and by a three LED lamp illuminating a white paper. The lights are measured by spectroradiometer. This phenomenon shows colour constancy between the two kinds of vision present in the human vision. The chromaticities of the lights in the two parts of the bipartite field computed for the standard CIE observers are different and show regularity on the chromaticity diagrams.

The apparatus for colour matching in a 2 deg bipartite field uses three wide band primary lights obtained by three halogen lamps combined with three interference filters and a spectral light obtained by a xenon lamp with a monochromator. The bandwidth of the spectral light is selectable by a set of different exit slits. The light exiting the two parts of the bipartite field are lambertian because diffused by two integration spheres. In such a way it is possible to select for any wavelength the narrowest slit with colour constancy and the largest slit with colour inconstancy, i.e. a range of bandwidths containing the threshold value between colour constancy and colour inconstancy is evaluated. The colour matching was checked true for foveal and extra macular vision and for three different individual observers. It results that for wavelengths  $> 510$  nm and for around 475 nm, the colour matching obtained with a slit of 0.5 mm, corresponding to a bandwidth of the order of 12 nm measured as Full Width at Half Max, is true for foveal and extra macular vision and for different observers. The bandwidth necessary for colour constancy grows rapidly out of these regions.

9/25 Tuesday  
15:40 PM



## Demonstration of the color constancy in picture

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### Abstract

It is commonly understood that the color constancy does not take in a picture. A white paper taken under an incandescent lamp appears very reddish when we observe it under a white light. According to the RVSI concept proposed by Ikeda the space recognition is the “must” for the color constancy. According to the concept when we enter into a space we recognize the space and understand the illumination in the space. Then our brain adapts to the illumination. The color appearance of objects in the space is determined by the brain. It is understandable why the color constancy does not take place in a picture because there is no space recognition for the picture. We know that the outside 3D scene is reduced to a 2D image on the retina, but we perceive a 3D scene again. This implies that the brain automatically changes a 2D image to a 3D image. This situation suggests that a 2D picture can be perceived as a 3D scene if the brain receives only information of the 2D picture without any others. In this paper we will show that the color constancy takes place in a picture by using a stereoscopic technique. A normal room was illuminated by 22 colors ranging from orange through blue via a white light and the corresponding photographs were prepared as picture stimuli. A subject observed the room and then picture stimuli with the stereoscope to choose a picture stimulus of which color impression was same for a real room illuminated by one of the 22 colors. Subjects chose the picture of which color is almost same as that of the real room. Subjects had a color impression for a room illuminated by one of the 22 colors and they had about the same color impression for the picture stimulus taken for the room illuminated by the same color. This shows that the subjects had the color constancy in the picture stimulus. We also confirmed that the color constancy did not take place when subjects observed the pictures without the stereoscope.

# Posters

in order of presenting session



## Investigation of the color appearance of color chips under bi-combinations of various light sources commonly used in indoor environments

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### Abstract

Light sources substantially affect the color appearance of objects. Color rendering evaluates how a color appears to an observer when it is illuminated by a particular light source. A color rendering index (CRI) is used to quantify color rendering of one light source. However, it is common to apply a combination of light sources in modern indoor environments. The purpose of the present work is to determine the correlation between the spectral power distributions (SPD) of components in the combination of various light sources. In this way, the effect of light combinations on color appearance of objects could possibly be estimated. The experiments were conducted according to a standard color order system. A set of the common light sources were selected as single sources and in bi-combinations to assess the color appearance of a series of reference color chips. The spectral power distribution of the applied light sources was measured by a CS-2000 spectroradiometer from Konica-Minolta. The results show the color appearance of the color chips is non-linearly related to the spectral power distribution of the combined light sources. Additionally, the color appearance of a bi-combined light source would very much depend on the similarity or dissimilarities of the spectral power distribution of the two utilized original single light sources.

## Evaluating color appearance and visual comfort of a living environment using a panoramic camera

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### Abstract

To improve visual comfort of our living environment, a colorimetric imaging device is designed to capture scene luminance and chromaticity for evaluating visual responses to the scene. To capture the scene over large fields of view, there are two main classes of techniques: image stitching (mosaicing) [1] or using omni-directional cameras. The former can achieve higher resolution but it takes longer time to complete the measures. The latter can use fish-eye lens [2] to cover a field of view up to 360x360 or use parabolic mirrors [3] to image a large field of view onto a single sensor. We choose the parabolic-mirror approach as it is the most efficient way to capture a 360 scene. However, the scene includes light sources and shadows normally. To measure the light distribution without signal clipping, panoramic images generated under multiple exposure settings can be fused together to obtain a high dynamic range panoramic image. It needs uniformity, tone-curve and color corrections to obtain accurate XYZ image. [4]

Color appearance of a large scene depends on not only reference white, but also local luminance. iCAM-based color appearance model [5] therefore is used to convert the absolute XYZ image into color appearance space. Color emotion models [6] can be applied in this space to estimate whether the color design of the living environment is suitable.

In the space, local contrast can be estimated to detect significant glare in the scene. Referring to CIE glare index [7], the proposed glare thresholds are viewing angle dependent. The thresholds are proportioned to the probability of viewing where horizontal direction is more critical. A psychophysical experiment was conducted to fine-tune the glare thresholds. Observers were asked to focus on the center of a 52" LCD TV to scale glare thresholds of color blocks with high luminance contrast in different sizes and vertical locations under dark surround. The resulted model can be used to evaluate visual comfort of a living environment in night time. More applications based on the panoramic XYZ image will be studied next.



## A study of color image in the urban waterfront space

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### Abstract

The research of environmental color was first proposed in 1960. Urbanized modern artificial environment has turned the concentration into overall study of the whole environment up to now. In the urban waterfront, Bridges, which represent an image of city entrance, plays an important roles on a city. The city could be infused new energy and fun, if we try to spray some color over it.

The disorder is mainly presented in the urban and rural of Taiwan because the environmental color is rarely discussed and estimated in a scientific way. For this reason, we use the method of surveying environmental color pronounced by French scholar Jean Philippe Lenclos, and the method of estimating urban image presented by Kevin Lynch as the basis of our theory. Moreover, we set the waterfront in Tamsui river watershed area in Taipei as our research regime to contrast the NCS of time line and space line with a roaming way over the river and field study method to collect the color image of the bridge over Tamsui River, including Taipei Bridge, Chung Young Bridge and QuanDu Bridge, the waterfront around rivers (close-view) , urban landscape (middle-view) , and mountain ridge skyline (far-view) . We use the color image meaning analysis proposed by Japanese color specialist Shigenobu Kobayashi and color recognizing tool of Sweden NCS (Natural Color System) to establish color information bank. At the same time we establish the environment main key color spectrum by the color territory discussion to realize the correlation between city waterfront and color images. Then by way of Color Harmony Theory, we can draft the environmental color design matter plan. We hope to provide bridge designers, landscape architects, urban designers, planners and all levels of government correlation unit as the future city waterfront essence plan designs and studies as the reference, and the color scheme also could be used in the mechanism of urban design review in Taiwan.

## Colors in preschools, between theory and praxis

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### Abstract

Preschools are special spaces for children personality development. The pupils, aged from 3 to 6 years, change rapidly, everyday. The intensity of change varies from subject to subject and the stimuli received are responsible for much of their development. The educators are familiar with the behaviors that children exhibit in this particular period of their life, especially because their communication is particularly evident, extroverted. In terms of color, this amplification produces a consequential adult behavior: they provide colorful spaces for children. In fact, usually strong colors are provided for pupil objects environment (toys, clothing, household goods, furniture, etc.) and for the spaces where they live. In particular, the preschools fully reflect this logic. We apply many different wall colors, sometimes using colorfulness, chroma and saturation often irritating. In addition, the colors of our society use color as a kind of conviction marketing weapon, increasing colorfulness, chroma and saturation. We can see colors affecting large segments of population, unaware of being unconscious tools for marketing purposes. These changes and the use of electronic devices in everyday life (different from the classical paper read/write) are stimulating educators to update their theories and approaches to the teaching in every school degree. Sensitized by this, as researchers, teachers and architects, we activated a research concerning a new approach to color in the schools.

The Municipality of Verona and the University Iuav, Colour & Light in Architecture research unit, signed an agreement to study the impact of the color choice in schools, from preschool to high school. The first exercise was, occurred as a result of the need for expansion and requalification of a small preschool, to try an approach using some wall colors for both internal and external spaces. The study case will be monitored over time. This preschool, situated into a suburb, was designed originally for only three classrooms. The enlargement consists in the addition of one more unit. This preschool is one of the few schools in Verona where children are separated by age, which is why the classrooms were only three. Most other preschools in Verona put together, with dramatic effects on the children development, pupils of all ages: 3,4,5. This pilot example, the "Giovanni Rodari" school, built around the year 1970, looks like a private home: pitched roof, external walls in scratched white plaster, brown shutters and white wooden windows. The interior is painted with lower band, high 1.50 m, in washable tint it seems without any criterion of choice, and the ceiling and the upper part of walls of water-based white paint. There is a law imposing, in public places like schools and hospitals, to have the first five feet from the ground made or painted with washable materials. It is in this space that the crime takes place, not excluding the floors and ceilings of rooms and common areas.

The paper will report on the experience of changing all the previous colors and the limits that such operation entails.

## Colour & smart technology for cultural heritage requalification and valorization

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### Abstract

European planning 2007-2013 identifies as priorities for the development the enhancement of infrastructures, the mobility of people and goods, the improvement of European town systems. The purpose of this attitude is the social, economic, environmental and management growth of local communities. Sustainability, participation and identity are the main conditions for a lasting development which consider life and environmental quality, information and culture as principles of a sustainable and culturally founded local development.

These are the basis for strategic urban planning, complex program, territorial marketing actions, cultural districts and integrated cultural systems. Among these new tools the concept of light art, site-specific and smart colour-technologies represent a possible local answer to the complexity of transformations imposed by global development, giving an efficient support to planning, to the valorization of knowledge, preservation of collective interests and quality of environment.

This study deals with the proposal of planning guidelines for valorizing the disused Venetian military heritage. The abandoned military heritage, present in the Veneto Region, is a system of great historical, cultural and environmental importance, quantitatively significant, which requires a specific approach with regard to recovery, valorization and management. In the case of fortified systems, these buildings cannot be read as isolated objects, but fall within organic defensive systems spread over the territory in the evolving history.

We would like to study a system of interventions involving the conversion of historical artifact in active, environmental responsive context in which the building is inserted. The "responsive architecture" measures the environmental conditions through a system of sensors allowing buildings to adapt their shape, color, or other functions in a reactive way. The use of latest technologies (nanotech and smart) with low environmental and economic impact allows designing and visually enhancing a type of building usually camouflaged in nature and the environment.

One of the targets is to improve the energy building performance through the application of embedded systems, integrating smart technologies in the building structure and in its envelope. This makes possible to directly relate the shape and building visibility with environmental stimuli. Guidelines for planning events and installations such as art and site-specific light will be provided using color and light for the environmental valorization of abandoned cultural heritage, visually connecting adjacent buildings in a kind of permanent installation, also variable and integrated with the contextual environment.

This research is part of a wider one conducted within the Research Unit "Colour and Light in Architecture" of the University Iuav of Venice. Precisely the research is coming from the Media Architecture Group, part of the previous mentioned Research Unit, involved in color and light phenomena on architecture and environment.

The paper will describe in detail the research program, some examples, and the outcomes expected.

## Color structure analysis according to the type of media façade as the construction materials

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### **Abstract**

This study is to ascertain whether the color structure of media façade with the function of construction materials is different from that of the general media façade for advertisements and if such difference can be analyzed. The methods adopted for the study are as follows: First, the case study was made with the media façades installed in Manhattan, New York, because the media façade was originated in New York and the current trends of media façade are led by them. After having surveyed the media facades in Manhattan, New York through the literatures, cases proper to this study were selected. Second, the selected cases were classified into four different types. Third, each case was measured by the naked eye using a digital camera and the color brightness photometer. The colors of each case were analyzed based on the CIE color coordinates for the color difference and chromaticity. As a result of this study, the method to measure the quantitative color distribution using the brightness photometer and CIE chromaticity coordinate diagram was drawn and the resulting values by the chromaticity area distribution and the distance value through the color analysis process could be acquired.

## Effects on color assessment depending on visual ranges in landscape

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### Abstract

It is generally believed that the humans' assessment of a particular color of an object in an environment differs depending on the distance between the object and the viewer. From the results of the previous studies, it is found that the chroma values decrease with an increase in the visual range by experiments to survey the relation between the "luminance" and the "chroma values". However, the effects on the humans' assessment of different colors in the environment, depending on the distance between an object and the viewer, were unknown. In this study, experiments were performed to quantitatively examine the effects on color assessment by considering three different visual ranges in the landscape.

The experiments were performed in the historic preservation district of Kurashiki city in Japan. 21 participants were selected for these experiments. First, color panels of A1 size (594 mm × 840 mm) were hung at the height of the 13M position from the ground level. The participants assessed each color panel in the landscape from three viewpoints, i.e., from a distance of 25 m (close viewpoint), from a distance of 50 m (middle viewpoint), and from a distance of 100 m (far viewpoint). The assessment indicators were constructed using 7 rating scales. The rating scales had four indicators, namely, conspicuity, harmony, vitality, and pressure. After the participants viewed each color panel, they assessed the panels on the seven-point scale. Then, simulation patterns were created under the following conditions. The color panels showed the following nine hues: 5R, 5YR, 5Y, 5GY, 5RP, 5BG, 5B, 5PB, and 5P. They also showed values of 5 and 8. Further, they showed three types of chromas, namely, 1, 3, and 6. In addition, the panels showed neutral colors 5 and 8. The experimenter prepared a total of 56 color panels using different combinations of hue, value, and chroma. It should be noted that the experiment was completed in approximately 2 h.

From the results of the analysis of the variance, the following three points were quantitatively demonstrated with significant differences. Small distance between the objects and the viewers had effects on the feeling of harmony and pressure with landscape. On the other hand, large distance between the objects and the viewers had effects on the feeling of conspicuity with landscape. It is interesting to note that the visual range had no effect on vitality.

From the above findings, it can be concluded that the assessment results differed depending on the distance between the objects and the viewers in the environment. In the case of the assessment from a close viewpoint, harmony and pressure should be considered carefully while designing a color environment. On the other hand, in the case of the assessment from a far viewpoint, conspicuity should be considered while designing a color environment.

## **New uses of color in urban open spaces - the constitution of a tool generating discourses in the French city of Nantes**

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### **Abstract**

“Slightly acid”, “flashy”, “kitsch”, “catchy” colored facades...If Modern Age suffered from a progressive erasing of colors in architecture, the city of today exalts and assumes a rich polychromy beyond the common “daily greyness”. New urban frames made of highly saturated colors emerge at a high speed in most of cities.

Our study is about understanding and analyzing the reasons which motivated the urban project actors in their use of color. The oral presentation will more specifically expose an exploratory work which aim is to survey contemporary architects and promoters on their use of color.

The method engaged is, firstly, the constitution of a tool conceived as a “reasoned” inventory of practical examples through which a multitude of architectural samples are analyzed in terms of color. The main way of restitution chosen is the architecture drawing. Considering how complex it is to read urban colorimetric images due to the numerous gaps between “real” color and its reproduction over colorimetric spaces, the drawing rehabilitation occurs to be the appropriate method for our research. As a proper tool for architects, it offers a certain malleability of rendering such as valorization of significant components, erasing of perturbing elements, free framing, panoramic recomposition, etc. As well, contrasts of heaviness, lightness, shine or materiality are sensitively treated through distinct mediums. The matter is not to focus on the exact reproduction of reality, but to re-interpret it expressively in order to create reactions.

Secondly, those samples are analyzed and classified according to a research on the use archetypology: urban location and visibility, colorimetric patterns (figures, proportions, contrasts), colored associations (marketing tendencies, esthetic obsolescence), materiality (optic effects, new material virtuality, variations due to movement), color accents, etc.

Following the constitution of this inventory, comes in a third part, the motivation of the architects on surveys. How do they integrate colors to their urban projects (conventional practice, experimental choice, political attendance, signaling position, chromatic study, imitation of references, artistic intuition, or application of colors ranges)? How do they anticipate the link between the colored object and its exterior environment (domination, signals position, uniformity research, harmony, disharmony, etc.)?

Then, this research project will be followed by the analysis of urban ambiances projected by colors. With this same tool, surveys on inhabitants can be carried out. What does color bring to city in terms of urban pleasure, appropriation of space? How do we anticipate the esthetic obsolescence of colors, the patrimonial conservation, the status or the architectural work through the concept of “the disposable facade”?



## Do people prefer grey? - A research on architectural color in changzhou

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### Abstract

Architectural color in urban has become one of the hot topics in China today. The researches and practices about architectural color in city have increased greatly in recent years.

This research is a pre-survey for making the urban color plan for Changzhou in 2011 of about 200 square kilometers. Our survey is about the present architectural color as well as the residential color bias for the present the future one. The survey for color bias includes two aspects of the present color attitude and the future one with NCS Cascade 980. And the investigation for the present architectural color includes color materials and functions with NCS index 1950 and NCS Color Scan 2.0.

The questionnaire consists of two aspect of the attitude of common people on the present architectural color in Changzhou city, and the expectation for the future for 6 aspects of the whole city, residential area, commercial area, industrial area, Administrative area, and official business area. We mainly assuming the non-structure type of 1086 pieces face to face with NCS Cascade 980, and others are from the web of 297 of effective pieces received.

The research group made an overall survey and evaluation on the present architectural color of the center city. The judgment is under 5 grades of best, better, medium, relatively poor and poor to evaluate the present building. The result reveals that those get the higher scores lay in the colored building, while those grayish ones which prevails in the whole city get lower scores.

Result reveals that the present façade color is mainly that of grey or near to grey, while the local people is inclined to the colored one. The conflict between the local people's expectation and the present color appearance make us research the city's culture from the history, as well as the reality and future. The research about the reason of the present greyish color and the goal of the color for future is the key for set out the color plan.

## Consideration of the area effect in color reproduction of a billboard

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### Abstract

Color design of a large-sized billboard is one of the important factors for environmental design.

A billboard is usually manufactured based on a proof (printed matter), which is examined and approved by a customer. However, the difference of color appearance between the actual billboard and the proof often brings a problem. This difference may be caused by several reasons, such as the difference of area of the object, the difference of distance between the view point and the object, and the difference of lighting condition (illumination, color temperature, etc.) . The last influence by the lighting condition may be predicted by the color appearance system, e.g. CIECAM. While the first two causes are modeled as one problem of the difference of visual angle, which is called the problem of the area effect.

This research reports how to quantify the area effect by a psychophysical experiment using a monitor and how to utilize the result to the manufacturing of an actual billboard.

Square images with visual angle of 2, 10, and 20 degrees were displayed on the monitor instead of a billboard. Four test colors, yellow, red, blue and green with a visual angle of 10 or 20 degrees were compared to the reference stimulus with a visual angle of 2 degrees of the same color. The result of the experiment shows that both of the lightness and the chroma of the visual field are monotone increasing functions of its visual angle. This quantitative evaluation of the influence of the area effect can be applied to determine the parameters of color reproduction of an actual billboard to satisfy the customer's request.

## New experiment data for evaluating colour rendering indexes

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### Abstract

Colour Rendering Index (CRI) is possibly the most important quality indicator of the lamps in the lighting industry. However, the current CIE CRI [1] has many weaknesses such as to use the off dated colorimetric tools and to predict narrow-band light sources poorly, such as light emitting diodes (LEDs). It is becoming one of the most important topics in CIE Division 1. There is a need to carry out experiment to evaluate its performance, or one step further, to develop a new CRI. Various experimental methods such as colour preference, colour discrimination, colour harmony can be used and the most widely used method is colour fidelity, for which its concept has been adopted in CIE-CRI [1] for many years. The results will be used to test the current CIE-Ra and most recently developed CRIs such as Colour Quality Scale (CQS) developed by National Institute of Standards and Technology, USA [2] and the other is the nCRI (based on CAM02UCS) developed by University of Leeds (UK), Pannonia (Hungary), British Columbia (Canada), KaHo Sint-Lieven (Belgium) [3].

We are currently conducting an experiment. Overall, 10 widely used commercial sources (F11, F2) including LEDs with different correlated colour temperature and D<sub>65</sub> daylight simulators are evaluated. Each of the 20 normal colour observers was asked to visually assess the colour shift of one of the 20 test samples between a 'Test' source and a 16 narrow-band LED source to generate 'Reference' source which has the close chromaticity match to the test illuminants following the CIE method [1]. The test-samples were well distributed in CIELAB space and were selected from the NCS colour atlas.

The CIE Technical Committee 1-69 Colour Rendering by White Light Sources is currently moving into critical stage to select a new index to replace the current method. The present results should contribute to their decision making. The data should also provide necessary information for each CRI developer to improve their index. In addition, a new index can also be developed in this study.

## A study on the evaluation of the color of a campus environment

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### Abstract

The purpose of this study was to analyze the importance of the image of the campus environment and to evaluate student's emotions triggered by the symbolic color of the campus.

The survey was divided into two parts. The first part surveyed the importance of the image of the campus environment. The short answer question was "What elements constitute the image of the campus?" The results of survey analyzed the frequency and grouping of the responses into superordinate concepts.

The second part of the evaluation focused on how the symbolic color of the campus affected the student's emotions. The target of this evaluation was Kansas State University (KSU), this campus which actively promotes symbolic color of university. Four representative colors of the KSU campus were extracted from landscape pictures using a mosaic screen process in illustration program. (The mosaic screen process is a way of averaging colors in picture.) The subjects were asked to evaluate the four extracted colors according to the 17 adjectives. These adjectives described emotional responses and were chosen based upon related studies by preliminary experiments. And the subjects evaluated their emotions using the seven-step Lickert's Scale. The subjects in all surveys included 30 students and professors who majored in architecture, urban design or landscape with expertise in environment design in KSU. The subjects represented a variety of countries. And the pictures of the target were presented for the subjects for evaluation.

The results of the study were plotted on a chart using factor analysis with each factor of influence plotted on the axis.

## Supporting system for color coordination of bridal space using genetic algorithm

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### Abstract

One of the most important issues for bridal coordinators is how to propose appropriate and satisfactory color coordination of bridal space according to clients' needs and preference. This skill is highly depend on experiences or tacit knowledge of coordinators, however from social point of view, this skill should be shared within not only mature coordinators but also amateur coordinators. Therefore the computer supporting system for color coordination of bridal space will be highly expected for especially amateur coordinators to be able to perform same as matures.

In this study, color coordination was formalized as an optimizing problem and using genetic algorithm the supporting system for color coordination was developed. Firstly for this purpose, 164 male and female aged between 20 to 30 years were required to evaluate their impression for over 200 photos of bridal space by 14 pairs of adjectives using SD method and at the same time colors of 6 parts of bridal space, i.e., ceiling, floor, wall, tablecloth, flower and chair, were measured by colorimeter. After that, the results of the factor analysis on above evaluation and cluster analysis (by Ward Method) on above evaluation and color measurement results of 6 parts, some statistical relationships are detected and data space constructed, where impressions and physical features of bridal space are linked.

The function of this supporting system is that can accept some adjectives presented by client's image and preference for bridal space as input data and appropriate and satisfactory color combinations of 6 parts of bridal space are proposed as output. This supporting system optimizes combination of colors of 6 parts using genetic algorithm, particularly matching functions to evaluate combination of 6 colors were formulated by relations between impressions and physical features of bridal space detected from above some experiments carried out in this study. Finally, system evaluation was launched by 52 male and female, as a result according to their impression as input date, system presented appropriate color combinations as output data and effectiveness and validity of this system has been confirmed.

## Exploring hues in communication from taiwanese min-nan dictionaries

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### Abstract

This study aimed to explore the color terms clustering in the local Min-Nan language, which is a basic research of color in the local language. The study sample was eleven Min-Nan dictionaries from Taiwan and we discussed three dimensions of color that included word interpretation, science, and culture. The results show the following. (1) The number of commonly used color names was the maximum, a total of 3,041. Their distribution is: “black” (909), “cyan” (578), “red” (573), “white” (441), “gold” (294), “yellow” (162), and “purple” (84). The black word group is mostly of the black radical. The color image generated from the different scenarios could be divided to describe the weather change and the hue of the object (charcoal, ink). For the cyan(青) word group, cyan, blue, and green were most easily confused with each other. In the Min-Nan, the description of color usage, “cyan” with a grass green, so immature, panic can also be cyan representatives. The use of “green” is modified through natural objects, such as “beetle green” and “banana leaf green.” The usage of the word “blue” to describe the sky and water, such as the blue sky, is the same as in the Chinese characters. The red word group is mostly of the silk(糸) radical. The word usage is also from the observation of the natural environment and everyday life. (2) Color modifiers can be divided into the following categories: “neutral colors,” “warm and cold,” “to describe hue changes,” and “quasi-physical.” Future studies can investigate the lexical color category space in the Min-Nan language.



## Color in iranian living room

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### **Abstract**

Making the color choices for the furnishings is truly one of the most important challenges for many people. Every color choice will convey different feelings and represent different taste and cultures, especially when people try to decorate their living spaces. Beyond the living spaces, the living room conveys cultural traits more than the other parts of the home and shows their feelings and lifestyle. Throughout history in Iran, even in the most primitive settlement, Iranians have manifested their interest in the bright and shining colors through the very application of them. Accordingly, the aim of this paper is to find the colors which Iranians choose for decorating and furnishing their living spaces today and the interaction between culture, history and everyday life. Twenty five samples of Iranian homes from the middle class society in different cities were chosen, observed and interviewed for this case study. For each sample, five preferred color schemes were found and a color pallet was created. To make the study possible, all the range of colors were categorized into ten main groups; Black & white, yellow, red, blue, orange, purple, green, brown, pink, and neutral colors, then each main hue was divided into nine subgroups which showed values in rows; dark, normal, light, and chroma in pure color, middle, and grey color in columns. Each subgroup is a sample for that range of colors. Three main pallets were found as the most popular colors in this survey: 1- Brown scheme from the lightest cream to golden, copper and brown 2- Dark brown with pink and dusty red 3- Warm shades between orange, red and brown. Generally, avoidance of vivid color schemes was observed. Despite sharp and bright traditional colors, people use a small or a single piece of colorful furniture, such as a brightly toned rug, and mention it as a special thing. For example, even though people still like the red traditional Persian rug, they prefer to have new dusty pink ones. In this survey two generations of Iranian couples, below and above 35 years old, were studied, but no meaningful differences were found between them and it defines the need of wide research in the history of last century of Iran's interior design.

## Development of browning scale of baked foods based on color measurement

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### Abstract

We measured the surface colors of plain cookies, sliced breads, and sauries (samma in Japanese) at various stages of baking, and made their color charts (browning scales) based on color measurements in the CIE L\*a\*b\* space.

For this study, a color image photographing system with a digital camera has been developed. A large spherical dome with a diameter of 600 mm, whose inner surface was painted white, was used to illuminate large food samples uniformly. Then, we placed food samples at various stages of baking in the middle of the dome. Two D65 fluorescent lamps were placed below the samples in order to illuminate samples only by indirect light. After the original images have been recorded with a digital camera, they were color-corrected using the X-Rite White Balance Card and X-Rite ColorChecker. Images taken by this system contain spatial information of food color. In this study, however, the averaged color values were used to make the browning scales. The baked color of each food was found to be dominated by the lightness, L\*; color changes in a\* and b\* of each food during baking were well described by the two-stage regression equations with L\*. Then, using these regression equations, browning scales of plain cookies, sliced breads and sauries have been developed.

Color is one of the important factors in determining food quality and is strongly related to the taste, smell, and texture of foods. It is known that properly browned toast, fish, steak, and other foods stimulate the appetite. Producing delicious-looking food is one of the qualities required of cooking equipment. It is necessary to accumulate preference data on food color and to develop a browning control method for cooking equipment. We believe that the browning scales made in this study are very useful and necessary in developing new cooking equipment.

## Color tolerance of copier paper: A comparison study between japan, korea and thailand

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### Abstract

The amount of using recycled paper is increasing with the consumers' awareness of globally environmental sustainability. Recycled paper should be produced as an environmental load-reducing by comparison with virgin paper. Consequently, the inferior quality of recycled paper is related to the eco-friendly products. It is thus necessary to know the acceptable quality level of recycled paper in use. The aim of this study was to investigate tolerances in terms of paper color and to study an influence of different cultural backgrounds on the consumers' awareness of recycled paper.

The focus of this paper is a cross-cultural comparison of the color tolerance level of recycled copier paper between Japanese, Korean, and Thai consumers. A series of visual assessments was carried out by thirty university students using a color palette consisting of 266 color samples that were arrayed in nineteen columns of hue and fourteen rows of lightness level in the same fashion in each country. The subjects assigned an acceptable lightness level for each hue as paper color. The assessments were carried out under the two hypothetical conditions: the paper was either recycled or not recycled copier paper. The responses were analyzed using CIELAB values of the color samples. It was found that three countries had similar results, that the color tolerance significantly increased ( $p < 0.01$ ) by the recycled assumption of copier paper. However, the degree of color tolerances of each color sample had different propensity in each country. The subjects of Thailand had less tolerance in both conditions than Japanese and Korean. In comparison with the differences between the color tolerances of the two conditions, the Japanese subjects showed higher tolerant levels than Korean and Thai. In addition, the results of correlation analysis showed that the lightness,  $L^*$ , contribution to the color tolerance was specifically higher in the case of the Korean subjects than the Japanese and Thai.

## A colorimetric analysis of coloration technique used in Japanese paintings by Itō Jakuchū

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### Abstract

This study describes a colorimetric analysis of the splendid Japanese paintings titled *Dōshoku sai-e* (E. Colorful Realm of Living Beings; c.1757–1766) by Itō Jakuchū (1716-1800). The paintings are composed of a set of 30 hanging scrolls with motifs of bird-and-flower. Last year NHK (Japan Broadcasting Corporation) planned to produce a special TV program for introducing Jakuchū's extraordinary coloration technique applied in *Dōshoku sai-e*, and gave us an opportunity to investigate it scientifically. High resolution images of the paintings were provided from NHK for our analysis.

In *Rogan-zu* (E. Wild goose and snow-covered reed), one of the scrolls, white color of snow covering on reeds is painted on dark grey background to highlight white snow. An area including the boundary between the snow and the background was sampled and measured. The Munsell value of the background neighboring the snow is less than the other area of the background. This tells that Jakuchū emphasized the contrast of the border (Chevreul illusion) applying black color next to the snow.

In *Shuro-Yūkei-zu* (E. Roosters and hemp palms), comb of one rooster is painted as a combination of red background and white dots. On the other hand, comb of another rooster is painted as a combination of red background and dark-red (blackish) dots. Color values of two combs were measured by two different methods and compared. One method is visual comparison of the comb as a unity with a standard color chip, and the other is calculation of the average color of the background and the dots of the comb based on additive color mixing model. The white-dotted comb looked brighter than the calculated color, and the blackish-dotted comb looked darker than the calculated color. This result suggests that Jakuchū already knew the assimilation effect and applied it effectively in his paintings.

It is interesting that these effective and unique coloration techniques of contrast and assimilation are devised in 18<sup>th</sup> century, preceding the publication of *De la loi du contraste simultané des couleurs, et de ses applications* (E. the principles of harmony and contrast of colours; 1839) by M.-E. Chevreul (1786-1889) and the establishment of pointillism by G. Seurat (1859-1891), a Neoimpressionist.

Lastly, we would like to introduce one more unique technique of Jakuchū representing golden color. In *Oimatsu-Hakuhō-zu* (E. White phoenix and old pine), body of a phoenix appears to have "golden texture." However, any pigments of golden origin (gold powder, gold leaf, etc.) are not used. Only ochre is used for expression of the yellow of "gold." Munsell values of the area with "golden texture" were measured. A gradation from dark gray to yellow is observed, which represents the characteristics of selective specular reflection on a gold surface. Plume of a phoenix is painted with bright white color (its Munsell value is greater than or equal to 8). This white may give us visual effect of glare which is always associated with gloss of metal.

## Colors and designs of pictograms used on the restroom signatures in international cities.

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### **Abstract**

Nowadays, with the aim of creating aesthetically pleasing communities, various signs in our environment are used to promote attractive planning.

Recently, signs with not only words, but also pictures, have become more popular outside bus stops, restrooms etc. Some newer signs, however, have caused difficulties because it is not easy to find the bus stop or restroom from looking at the sign.

However, it is very difficult to improve the visual impact of these pictograms because such factors (the picture being too small, the color that it is hard to look at being used etc.) are not taken into consideration where they are designed.

In color planning, it is important to consider how colors will be perceived and how they can convey the points of pictograms easily. Therefore I have considered that it is more useful to improve the visual impact of the pictograms than to just evaluate the colors which are used.

Here, I report the results of my survey concerning pictograms indicating restrooms. They consist of the aspects of the pictogram's visual impact: the colors of the target and its background, used in public areas in Osaka, Japan, Seoul, Korea and San Francisco, USA.

The survey includes an evaluation of 100 points from famous central stations, hotels and shopping centers from the data of the 3 cities mentioned above. The data of this report consists of 40 points in Japan, 30 points in Korea and 30 points in the USA. I have examined colors used for each pictogram. This data consists of the Munsell color values, materials, and the size of forms. The survey shows there is very little difference between Japan and Korea but more of a difference between Asian areas (Japan and Korea) and the USA.

The conclusions obtained from this survey, are not always suitable to our living environments immediately. But we can suggest how to improve the current pictograms and how to change them to achieve a better visual impact.

## The relationship between color harmony and color affective feelings-using 3d color configuration

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### Abstract

Many studies have been devoted to the color harmony. It was found that these studies only used 2D shapes to study color harmony. This led the results impractical for product design, because the shapes of product are usually three-dimensional shapes. Additionally, for product design, designers seek not only color harmony but also the affective feelings of color combination. Hence, the current study carried out a psychophysical experiment using a series of color combinations applying on 3D shapes to see color harmony and color affective feelings of 3D color configuration.

Thirty-two observers with an average age of 24 years old took part in the experiment, including 19 male and 13 female. Each observer was asked to assess 122 experimental samples on 6 scales, including “harmonious-disharmonious”, “active-passive”, “heavy-light”, “warm-cold”, “soft-hard”, and “complex-simple”.

In terms of experimental sample, 11 basic color terms according to Berlin and Kay (red, orange, yellow, green, blue, brown, purple, pink, white, black and gray colors) were used to be main color. Each basic color term was produced according to their boundaries in CIELab space proposed by Lin *et.al.* Four design techniques were used to produce secondary colors, including “tone in tone”, “tone on tone”, “tonal”, and “chromatic color and achromatic color”. Totally, 122 color combinations were produced and applied onto the cuboids (10cm × 6 cm × 1.5 cm) with side circle. The main color was applied onto the cuboids shape, secondary color on side circle. Each color was measured by a GretagMacbeth® Eye-One. The CIELAB values were calculated under CIE D65 and 1964 standard colorimetric observer. This experiment was conducted in a dark room. 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.

In prior to analysis, the observer repeatability and accuracy were examined by root mean square. The former is to see whether the observers can repeat their judgment or not. The latter is to examine how well the individual observer agrees with the mean results.

The correlations of “harmonious-disharmonious” to other scales were calculated ( $r=0.84$ ). Only “complex-simple” was found to be correlated with color harmony. A structural equation model was hypothesized. This model was verified by regression analysis. The results showed that the performance of the model was significant. It was indicated that color harmony was modeled by both “complex-simple” and “warm-cold”. And the scale of “warm-cold” was modeled by “active-passive”, “heavy-light”, and “soft-hard” scales. For seeking color harmony, the current model suggested designers that both “simple” and “warm” feelings can prompt “harmonious” feeling. The former feeling is more influential than the latter feeling. In addition, this model suggested “active”, “heavy” and “soft” feelings can prompt “warm” feeling, indirectly prompting “harmonious” feelings.

Review the previous studies related to the color emotion. The “active-passive”, “heavy-light”, and “warm-cold” were found to be independence. However, for color harmony on 3D color configuration, these emotional scales were found to have interaction effect and have indirect influence on color harmony.



## Color categorization of color deficiencies , effects of illuminance and categorization correspondence to normal trichromat

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### Abstract

Basic color terms based on color categorization are often used to communicate. They are useful to designate or distinct objects then colors are widely used on application like signals, signs and so on.

When we use color for the purpose, it is needed that the same surface (i.e., object) is always seen the same color category even if it is seen by various people. It is pointed out that it sometimes does not stand up to color deficiencies caused by their different color characteristics and it is important to evaluate how much color deficiencies can categorize color as well as normal trichromat by seeing.

We carried out a categorical color naming experiment to color deficiencies and young adults to investigate the effects of illuminance on color categorization. Three levels of illuminance (10, 100, 1000 lx) with D65 fluorescent (D-EDL-D65) were employed. Sixteen young adults with normal trichromat (aged in their 20 years), seven color deficiencies (two-protanopia, five-deutanopia) participated in the experiment as observer. A series of Munsell color chips was used as stimulus. Each color chips were presented separately and observers were asked to categorize the chip into one of the eleven basic color terms (red, pink, orange, yellow, green, blue, purple, brown, white, gray, black) in each trial.

The results showed that illuminance level affected color categorization especially to color deficiencies. The color categorization of young adults changed very slightly by illuminance, meanwhile the categorization of color deficiencies changed abruptly. The consensus between the categorizations by the young adults and color deficiencies more improved, as the illuminance level was higher. We also have found that there were some color chips whose categorization was same regardless of observer group or illuminance. The each centricity in Munsell space was 5PB4/10 and 10B6/8 for blue, 5RP6/8 and 5R8/6 for pink, 5G6/6 for green, 10R6/12 for orange, and 5Y8/10 for yellow.

The results can be utilized to consider visual environment from a perspective of color universal design. When the surface is used to communicate by its color category, the surface should be indicated in well-lighted space. Insufficient illuminance would more affect the categorization of color deficiencies. The five color categories mentioned above could be the safe colors for communication by color category.

## Analysis of Color Design of Broadcast Channel Identity : Focusing on color design of Korean women lifestyle channels

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### Abstract

As viewers have become the center of broadcasting by selecting from various channels from the increase of broadcast channels, each broadcasting channels are building their own unique and distinctive image to increase competitiveness and strengthening the brand of the channel. Color is the first aspect among the visual factor in passing messages and determining the overall atmosphere in sensitivity; it is used as an effective method in granting channel identity. Therefore, the differentiation of color rules is expected to exist depending on each targeting viewers. In this paper, the main target was the Korea's women lifestyle channel's color design analyzes reports of the broadcast channel differentiation strategy. Women's lifestyle channels; „Onstyle" , „O'live" , „FashionN" , „Channel donga" ; among each channels" Station ID, eight scenes were captured and each scene main color, sub color, and emphasis color was made up to compose a coloration band. Then these were applied to the single color image scale to find out the colors that identify each broadcasting channel.

Results of the color analysis show that main color and sub color represents feminism through symbolic analysis. All three channels except for FashionN all uses color purple while FashionN uses color red which are colors that represent women and this shows directly and indirectly that these channels are mainly targeting women viewers. Secondly, the main color and accent color shows modern feminism. The main colors of all four channels are located in the soft-dynamic region in the single image scale which represents the confident and active image of modern women, also personal and free-spirited purple was used as the main color to represent the image of brilliant women.

In addition, FashionN uses color red and black to represent the passion and enthusiasm of the women by the intense and vibrant color scheme. Finally, the color scheme varies depending on the age range of the viewers. Channel donga and O" live uses achromatic colors with high value for the background to accommodate people of wide range of ages. On the other hand, FashionN uses strong mixture of red and black color to target the single women which are the largest consuming class.

The consistent of the color regulation of each channel establishes the channel image and can be an effective marketing tool to improve the identity and competitiveness. Especially, for the woman life style channels which target the largest consuming class of 20-30 women are establishing the channel identity through identity color which represents their sensibility.

## The effects of surround luminance on the color perception of outdoor LED panel

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### Abstract

Outdoor LED panels are increasingly popular to use for advertisement. It is found that the perceived color appearance on the LED panel is significant different viewing in bright sunny day and dark night. In this study, a psychophysical experiment using magnitude estimation technique was conducted to investigate the effects of the surround luminance on the perception lightness, colorfulness and brightness. A total of eighteen test colors with various lightness level and chroma produced on LED panel were assessed by 10 observers in dark, average and bright ambient conditions. The color coordinates of the test colors were measured by PR650 TSR and color space CIELAB were used. Each test color was placed on the wall and surrounded by grey background with average luminance  $80 \text{ cd/m}^2$ . The luminance of the reference white used in the LED panel was  $350 \text{ cd/m}^2$  and the luminance of the dark, average and bright ambient condition were 0,  $350 \text{ cd/m}^2$  and  $10^4 \text{ cd/m}^2$  respectively. The experimental set-up is shown in Fig.1. The observers were asked to assess the test colors in terms of lightness colorfulness and brightness. The experimental results indicate that the lightness and brightness are larger when viewing in dark and the lightness and brightness are smaller when viewing in bright sunny day. The accumulated data set was also used to test CIECAM02 and CIECAM02-mobile proposed by Park YK. et al. The results are shown in Fig2,3. .

## Gender difference in judging facial attractiveness based on skin tone

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### Abstract

Two psychophysical experiments were conducted to investigate gender difference in judging facial attractiveness by skin tone. In Experiment 1, a computer-generated young human face image was used for creating 12 face images with manipulated skin tones. Fourteen male and 15 female British observers participated in the experiment. In Experiment 2, two original young Caucasian face images (a male and a female) were used for generating 22 face images varied in skin tone. Eighteen British observers (consisting of 9 males and 9 females) took part in the experiment.

The results of Experiment 1 show that the male observers seemed to be more sensitive to hue than the female did, while the female data looked to be affected by chroma more than male data. The results of Experiment 2 show that the two gender groups disagreed with each other much stronger in judging female faces ( $r=-0.44$ ) than in male faces ( $r=0.58$ ). The female face images with skin tone in the low-chroma, yellowish hue region looked most attractive to female observers, whereas those in the high-chroma, reddish hue region were rated most attractive by male observers. The female observers gave the highest ratings for male faces with a skin tone at a hue angle of around  $33^\circ$  to  $42^\circ$ , with a chroma value of around 20; for the male observers, on the other hand, the male faces with high chroma and hue angle around  $42^\circ$  were most attractive. In addition, the higher the chroma is, the more attractive the male face appeared to male observers. Results of the two experiments suggest a stronger gender difference in skin color preference for female faces than for male faces, and that the clearer the gender characteristics of a face image, the more gender difference in judging facial attractiveness.

## Studies of Blackness Preference and Perception

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### Abstract

Black is a multi-dimensional and important colour in our daily life. It is particularly important as ink in printing systems and many black inks include a number of dyes or pigments. Therefore, black inks exhibit slight differences in colour. Which hues appear most black? And do observers have a preference for some hues over others in terms of blackness? This study aims to explore blackness preference (observers were asked to indicate which of two black samples they preferred) and blackness perception (observers were asked to indicate which of two black samples they considered to be closest to a pure black) for observers from different cultures (defined in this study by gender and nationality).

There are three dimensions of colour: hue, value and chroma and this study is focused on value and chroma. An earlier study considered blackness perception and preference with particular emphasis on the effect of hue. In that study neither nationality nor gender had a high impact on blackness perception. However, the results showed clearly that colour preference of blackness was influenced by nationality particularly (and by gender to a smaller extent). Interestingly there was also a difference between blackness perception and blackness preference. Though most observers perceived the darkest and least chromatic samples to be the most black, these samples were not judged to be the most preferred blacks. Most observers expressed a strong preference for bluish blacks and a lesser preference for yellowish blacks. The aim of this research is to further explore the difference between perception and preference for black and to seek to validate the effects of nationality and gender that were found in the earlier work. In this study the samples varied predominantly in value and chroma.

So this study investigates preference for, and perception of, blackness using psychophysical experiments. A total of 29 black samples (varying in value and chroma) were evaluated for colour perception (which of two black samples observers considered to be closest to a pure black) and colour preference (which of two black samples observers preferred). For colour perception there was no statistical difference between UK and Chinese observers nor between male and female observers. However, for colour preference there were effects of culture; Chinese observers preferred darker samples and UK observers preferred lighter samples.

## Implicit attitude toward colour: Trials for analyzing colour preference using implicit association test (IAT)

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### Abstract

In the present investigation, we tried to analyze implicit attitude toward colour, using implicit association test (IAT). IAT is recognized as one of the most conventional method in measuring implicit attitude in psychological studies. In IAT, participants discriminate target word into two criteria. In the condition where the psychological concept which are implicitly associated are paired in discriminatory criteria, the participant's reaction is facilitated (reaction time is reduced), vice versa in the condition where the psychological concepts without implicit association are paired. IAT utilizes differences of reaction time in categorical judgment in order to measure participants' implicit attitude, independent of participant's conscious and arbitrary indication.

26 undergraduates participated in two psychological experiments. In experiment 1, the participants executed IAT measuring implicit associations between preferred colour/hated colour, which was explicitly selected, and psychological concept of pleasant-unpleasant. We also measured participant's cognitive styles on colour in daily life with conventional psychological scales, and divided participants into four groups (high and low colour consciousness and colour stereotypes). Result of experiment 1 indicated that preferred colour and pleasantness were implicitly associated with each other. Implicit association between preferred colour and pleasantness was relatively stronger in the participants with lower colour stereotypes and higher colour consciousness, as compared with the participants with lower colour stereotypes and lower colour consciousness. In experiment 2, IAT measuring implicit association between preferred colour and psychological concept of self was executed with the same participants as experiment 1. Experiment 2 revealed that, preferred colour significantly associated with the concept of self. The result was consistent with the previous investigation which indicated that mental image of preferred colour which was explicitly measured with semantic difference method was similar to the one of the self.



## **A study on people's preference and imagery of house color**

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### **Abstract**

What effect does color have on people's feelings and imagery with regard to their immediate living environment? This study analyses people's preferences of outside wall color of single houses. In order to find out about people's preferences for colors of the outside appearance of a house, their imagery of preferable and aversive house colors, and the relations between color preferences of houses and cultural and demographic variables, a computer-based experimental survey has been conducted with 123 subjects of Chinese Culture University, Taipei. A series of images made from a 3D-model with 30 different texture colors were chosen to ask for color preferences.

Eight semantic scales consisting of 8 bipolar word-pairs (Dislike-Like, Ugly-Beautiful, Hard-Soft, Cool-Warm, Vulgar-Elegant, Discreet-Loud, Masculine-Feminine, Unpleasant-Pleasant) were used to derive imagery with a 7-step Likert scale. Results show that people favor the colors S-3020-R70B, S4030-Y60R, and S3020-Y80R, but dislike S3040-Y, S2010-G90Y, and S5000-N (NCS notation) for their house color. No significant interaction has been found between demographic variables and color preference of house colors.

The results show clearly that as long as a person likes the specific color, it will be felt as beautiful, soft, warm, elegant, and pleasant; while if one dislikes the specific color, it will be treated as hard, ugly, cool, vulgar, and unpleasant.

Subjects who thought themselves as extravert personalities tend to rate with wider range while people thinking themselves as introvert tend to rate within a narrow range.

## Colour preferences: a British/Indian comparative study

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### Abstract

A robust gender difference in colour preference among British participants has been reported by independent studies (Bonnardel et al., 2006; Ling et al., 2006). While both males and females showed a preference for blue colours, females further expressed a preference for pink-purple colours. Assuming that colour preference results partly from social constructs conveying information about individual identity, a colour preference task was conducted together with International Personality Item Pool (IPIP) and the Bem Sex Role Inventory (BSRI) questionnaires to investigate possible correlation between personality, gender schemata and colour preferences.

The colour preference task consisted of 16 stimuli based on the D15 colour test, located at roughly equal intervals on the hue circle, presented in triads on 4 cm squared cards. Ten stimuli (5Y, 2.5YR, 7.5YR, 5RP, 10P, 5B, 10BG, 10G, 5G & 5GY) had the same brightness and saturation (Munsell value = 5 & chroma = 4). The other six stimuli (10B, 5BG, 10GY, 10YR, 2.5 R and 5 P) were lighter and less saturated (Munsell value = 6.5 & chroma = 3). (Bimler & Kirkland, 2009).

The preference curves obtained for 43 female and 37 male English Psychology students revealed a similar gender difference with a common preference for blue and blue-green colour and a female-specific preference for purple over yellow and orange colours. The gender-specificity of the colour preference pattern was further supported by exclusive correlations of colour ranking with BSRI scores for females, and with IPIP scores for males (Bonnardel & Lanning, 2010).

Preliminary colour-preference curves obtained with Indian participants (NID) suggest the presence of a gender difference of a different kind based on saturation-brightness rather than hue. Indian males' colour preferences share similarities with British males, expressing their preference for the blue-green sector of the colour circle. On the other hand, Indian females show a preference for saturated-brighter samples over desaturated-darker samples, with no clear indication of a preference for purple over yellow-orange colours as reported by British females.

Results of this study will inform further on pan-cultural versus culture-dependent factors underlying observed gender differences in colour preferences.

## Consumer preference and expectations for coffee colour used in advertisement

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### Abstract

Colour is the first impression which can make consumers interested in products, especially in food and beverage products. Colour appearance signifies quality and character of the food. The relationships between package colours and expectations of consumers had been studied by many researchers. As well as the package design, colour used in advertisement has impact on marketing communications. An appropriate use of colour could stimulate consumers' purchase motivation.

Espresso is the main type of coffee consumed almost in all parts of Europe and also popular in many other countries throughout the world. It is the base for other drinks, such as a latte, cappuccino, macchiato, mocha, or americano. One of the factors used to judge the quality of espresso is its colour. The top layer of espresso, called crema, should be hazel colour for the best espresso.

This study investigated associations between the colour of espresso coffee in prints and consumer expectations. The image of espresso in a white cup was combined with a complex background similar to that used in advertisement. Forty printed samples of espresso coffee having different colours only in the coffee part with the same colours for the rest of the image were evaluated by 40 Thai observers, including 10 experts who worked in a coffee company researching and developing coffee and 30 general coffee drinkers. Each observer viewed one sample at a time in a light cabinet illuminated with D65 simulators. Observers were instructed to evaluate each sample using a 1-9 rating scale, with the ends verbally anchored with "not" to "very". For example in the sweetness scale, 1 rating represented "not sweet" and 9 rating represented "very sweet". Eight expectations scales including preference, intention of purchase, quality, flavour strength and expectations of tastes: sweet, bitter, sour and astringent, were investigated. Statistical tests revealed that the results from two observer groups were significantly different. The results from factor analysis showed that the experts related the scales of quality, intention of purchase, preference and sweetness with the levels of chroma and lightness: when chroma and lightness increased, the visual scores of these scales increased. On the other hand, the general coffee drinkers associated chroma and lightness with the scales of flavour strength, bitterness, astringency and sourness in a reverse manner: when chroma and lightness increased, the visual scores of these scales decreased. The experts preferred espresso images having high lightness and yellowish colour, which is the colour of crema, whereas the general coffee drinkers preferred the images with low chroma and lightness, as they associated them with strong flavour.

## The comparative study of psychological cognition of black as fashion color in japan, china & u.s.

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### Abstract

From culture to culture, black seems to be regarded as a key color of fashion in various occasions, such as ceremonies, uniforms, etc. The literature review shows that the frequency of wearing black for everyday life is relatively higher than other colors, and black seldom changes in the trend colors every season. This research focuses on the psychological background of choosing black as fashion color by doing the online questionnaire in Japan, China and U.S.

The subjects with the total number of 300 are undergraduate students, graduate students and company employees, who are living in Tokyo, Shanghai and New York, and age from 18-35 years old. They were mainly asked to evaluate the impression of black, describe the association of black, and choose their own reasons of wearing black for both public and private occasions. Factor analysis was used to figure out the feature of each district about the sense perception and emotional conception of black. Analysis of choices by correspondence analysis showed the tendencies for black preferences in fashion with discussion over the similarities and differences. Moreover, the significant differences among the 3 districts were statistically verified by Chi-Square Test. Furthermore, a successive study of analyzing the psychological cognition of black as fashion color has been conducted comprehensively by taking the cultural and social situation of each country into consideration besides the regards to genders and occupations of subjects.

As the prospects, the demands of consumers will be clear after the investigation of the psychological impacts from the color of black on consumers under different circumstances of the 3 countries. As a result, the fashion industry will expand, and the quality of life will be improved as well as the economic development.

## Monte-Carlo simulations for paired-comparison experiments

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### Abstract

Incomplete paired comparison is an important technique for color-imaging problems because it can avoid observers to compare every possible pairs since the number of paired comparisons for  $n$  stimuli is  $n(n-1)/2$  which becomes prohibitive for large values of  $n$ . However, the experimental designer often struggles with questions such as what is the smallest limit the proportion of paired comparisons included that will still allow reliable estimations of scale values? How many observers should be invited for an incomplete paired-comparison experiment? If it's possible is it better to let each observer evaluate a different set of pairs of stimuli? The previous work developed a framework for addressing these practical questions surrounding the design of incomplete paired-comparison experiments where each observer in an experiment evaluates the same set of proportion of paired comparisons. This work seeks to explore the effect from the number of observers and proportion of paired comparisons on the accuracy of scaling results for paired-comparison experiments where each observer evaluates a different set of paired comparisons and also compare the performance of these two experimental designs. The work also seeks the answer for the question whether the pairs in the incomplete paired-comparison experiments selected in a certain pattern could improve the performance of estimation of scale values. Again Monte-Carlo computational simulations were carried out with an ideal observer model assigned a bias. The results suggest that both the proportion of paired comparisons and the number of observers are critical for small-scale experiments with less than 15 observers and 30 stimuli, but for large-scale experiments with more than 15 observers and 30 stimuli both factors become insensitive to the performance for the incomplete paired-comparison experiments where each observer evaluates a different set of stimuli. The results also indicates with the same number of observers and stimuli, the experimental design with each observer evaluating a different set of data require much less proportion of paired comparisons to achieve the same or even better performance than the experimental design with each observer evaluating the same set of paired comparisons. In addition, the results shows that whether the pairs of stimuli are selected in a certain pattern or randomly selected have no significant influence on the performance of estimation of scale values in incomplete paired-comparison experiments where each observer evaluating a different set of stimuli.

## The impression of tones and hue in gradation of practical color co-ordinate system (PCCS)

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### Abstract

Practical Color Co-ordinate System (PCCS) was developed by the Japan Color Research Institute in 1964. The feature of PCCS is "Hue-Tone system". Tone is made up of value (lightness) and chroma (saturation). Thus color is represented by two attributes that is hue and tone. PCCS tones were consisted of twelve tones and these have individual image, for example: "dark" tone colors (low value and middle chroma) have heavy and dim image; "vivid" tone colors (middle value and high chroma) have bright and clearly image. This image is common, when it is the same tone even if hue is different. Although hue, value, and chroma have been investigated, there is little investigation about a tone, and almost all studies of PCCS are written in Japanese. Moreover, these studies were investigated mostly in 1960-1970's. It is thought meaningful to investigate the tone since it is original concept and almost studies of tone have passed few decades. The purpose of this study is to investigate the influence of color, particularly tone and hue of PCCS.

Eleven PCCS tones and achromatic color (gray scale) were used for tone stimuli. Tone stimuli (twelve hues - 1.5cm×1.5cm) were pasted in a circle on a neutral gray mount (10cm×10.5cm). A chromatic color stimuli (nine color chips - 1.5cm×0.7cm) were pasted in a row on a neutral gray mount. The typical twelve colors in PCCS were used as a hue stimuli, each stimuli (eleven tone color chips - 3cm×1.5cm) were pasted in a row in gradation (order from which value and chroma change) on a neutral gray mount (5cm×21cm). In total, twenty four stimuli were used. The seven points semantic differential method was used which included a questionnaire consisting of twenty pair words. The subjects looked at each color and answered the questionnaire. One hundred fifty subjects joined in this experiment.

As a result, it was indicated that the effects of combining tone and gradation hues differed from the individual effects of tone and gradation. The following results of factor analysis were obtained for four factors. This result was able to clarify the difference in the impression of each tone and hue.



## Individual differences in macular pigment optical density and color perception

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### Abstract

It is well known that there are individual differences in color perception, but factors that determine the individual differences have not been fully clarified. Macular pigment is considered as one of these factors. It lies in front of the fovea, and absorbs some portion of the visible light (about 380-520 nm). It is reported that the macular pigment optical density (MPOD) differ among people. Therefore, there is a possibility that individual differences in color vision are mediated by individual differences in MPOD. The purpose of this study is to clarify whether the individual differences in MPOD correlated with individual differences in color perception.

First, we measured MPOD of 48 subjects (male: 44, female: 4), using heterochromatic flicker photometry (Experiment 1). Second, we conducted the color matching experiments for 11 subjects who participated in Experiment 1 (Experiment 2). In Experiment 1, subjects were presented flickering stimulus: the reference LED light of 570 nm, and the test LED light of 470 nm. The alternation frequency was 20 Hz. The LEDs were placed in an integral sphere, and the subject viewed the stimulus through an aperture of 1.6 degree visual angle which was located at the center of a hemisphere dome. Inside wall of the dome was illuminated with a D65 fluorescent light. Its intensity was 47cd / m<sup>2</sup>. Experiment was conducted in two conditions: foveal viewing and peripheral viewing. In each condition the subject adjusted the luminance of the test light so that the flicker disappeared or minimized. MPOD was obtained from the intensity ratio. The mean MPOD was 0.385 ( $\pm 0.123$ ), with the minimum of 0.071, and the maximum of 0.671. Thus, large individual differences were found in MPOD (about 0.6).

In Experiment 2, subjects conducted color matching experiments using a bipartite LED system which was reported previously.<sup>1)</sup> The subject adjusted the color appearance of the test stimulus by changing the intensities of three primaries (R:626nm, G:524nm, B:472nm) until it matched the color of the reference stimulus. Color matching functions (CMFs) were obtained for 12 different wavelengths. There observed individual differences in CMFs.

Both results showed individual differences. The significant correlation, however, was not found between these results, even in the short wavelength region, where the absorption of the macular pigment may affect.

## Effect of different sample types on color harmony

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### Abstract

The effect of different types of sample modules in multiple-color combinations was investigated using 45 samples of fashion apparel images having various color combinations were accumulated in this study as an original set of experimental samples. And, three another sets of experimental samples were also emerged from the original one in apparel-image without human form, arranged color block and traditional color block respectively. All the four sets of experimental samples described above were used in different sections of color harmony-assessment experiments separately. The experimental results indicate that the two sets of arranged color-block and traditional color block samples have the performance in relationships of three color attributes separately relative to color harmony being completely different from these made by on other two sets of samples in fashion apparel image and those pattern without human form. One the other hand, both the original set of fashion apparel images and the set of those without human form have good consistent performance and effect on those relationship among three color attributes and color harmony respectively. This new finding may imply that the color-harmony assessment on multiple-color combinations of fashion apparel is regardless of human form to the apparel image.

## Effect of image category on acceptability and perceptibility of color difference in natural images

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### Abstract

It is important to match color reproduction between devices dealing with color information. However, color-difference formula ( $\Delta E_{ab}^*$ ) does not sufficiently reflect color differences perceived in images. Researches on the detectability of image color difference have been conducted in order to establish a method to describe color differences between images. It has been shown that the detectability is largely different depending on images, suggesting that image category is important factor for image color difference. Furthermore, detectability is a useful indicator on color difference, the acceptability of image difference is an important indicator as well, especially for practical use. Here, the acceptability can be defined as image difference that maintains the overall impression of the original image. The purpose of this study is to investigate the effect of image category on two criterion, acceptability and detectability in image color difference.

Ten images were used in experiments (three images of landscape, three images of still life, four images of portrait). Each image was manipulated by a contrast modulation in each channel  $L^*$ ,  $a^*$ ,  $b^*$ . Referring to one of two natural images that appear on a display, an observer changed the degree of contrast modulation until the limitation of acceptable difference from the other by the method of adjustment. In the case of detectability, contrast modulation was varied until a detectable difference from the other. Acceptability and detectability were measured in each channel  $L^*$ ,  $a^*$ ,  $b^*$  for each image, respectively. Four color-normal observer participated.

As a result, the smaller detectability is, the smaller acceptability is in general. This suggests that acceptability would link with detectability. However, it is also suggested that difference in image category has more influence to acceptability than detectability. The acceptability of  $L^*$  was large for landscape images. This is probably because we are used to landscapes with the variety of brightness on a daily basis. On the other hand, acceptability and detectability of  $L^*$ ,  $a^*$ ,  $b^*$  tended to small for portraits, suggesting that we are sensitive to changes in skin color. For still life images the results showed large individual differences. One possible reason would be a difference in the criteria between the subjects depending on the objects of interest.

## A novel method to measures color-matching functions

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### Abstract

Color Matching Functions (CMFs) have been widely used to calculate the tristimulus values. CMFs are the intensities of three primary lights required to match the equi-energy monochromatic lights. There are, however, individual differences in the CMFs even among people with normal color vision. In order to quantitatively evaluate the degree of color mismatch between observers, it is necessary to know CMFs of those observers. However, it is not easy to obtain individual CMFs. The difficulties come not only from the complexities of the optics system which is used to measure CMFs but also from the stress of the subjects. As for the complexity of the system, we have succeeded in building a simple and compact apparatus with LEDs, which was reported previously.<sup>1)</sup>

In most of the researches which tried to measure CMFs, an adjustment method was adopted, in which a subject adjusted the intensities of three primary lights to match the color of the test light. In this method, the subject had to adjust the intensities of three primaries simultaneously. This large degree of freedom often gave a naive, or un-experienced, subject a great stress for the experiment. In this study, we propose a novel method which adopts an Alternative Forced Choice (AFC) method. There are several advantages in this method. First of all, all the things that the subject has to do is merely to look at the stimulus and judges whether it matches the criteria or not. Thus, it is expected that this method is not stressful for subjects.

In AFC, a subject was asked to evaluate the similarity between the test and the reference stimulus. Several reference stimuli were prepared in advance. During the experiment, the subject could change the reference stimulus with a button on a controller. A subject selected the most similar one among those the stimuli.

The preliminary experiment was conducted for 12 different monochromatic lights. As reference stimuli, the mixture of R, G, B primaries were presented. Their peak wavelengths were 629, 523, 471nm, respectively. As the reference stimuli, 7 different mixture ratios of R, G, B primaries were prepared. The luminance of the test stimulus was set to 2 cd/m<sup>2</sup>. A surrounding annular stimulus was presented to the observers to prevent from dark adaptation.

4 subjects participated in the experiment, and they conducted 3 sessions. We could obtain almost the same results with our methods as those obtained with the traditional adjustment method. The total time required to complete a session was also almost the same for these two different methods. Some observers reported that our novel method was less stressful and comfortable. Although the color of the stimulus changed discretely in color space, nobody complained in this point. This results indicates that our method has several advantages in measuring CMFs, especially those of a naïve observer.

## Subjective evaluation of metal like appearance for estimating the determinants of material perception

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### Abstract

We do not know which features of objects contribute to a material perception. It is helpful for create computer graphics if we know the relevance. This paper presents the results of subjective evaluation of metal like appearance for estimating the determinants of material perception. Images of a ball which have various parameters are generated using computer graphics software. The parameters are five step on four types (reflectance, diffuse reflectance, first gloss, and second gloss). Subjects experiment is conducted with the 36 images and using five step rating scale method. 56 observers (males and females, ages 20-24) took part in the experiment. A degree of metal likes is decided on mean of the results.

We use multiple regression analysis to quantify the degree of metal likes. An objective variable is the degree of metal like, and explaining variables are parameters of computer graphics. From results of the analysis, we select parameters which are high relevance.

The regression function  $M$  is described as follows:

$$M = -1.53d + 0.91s + 2.28r + 1.32 \quad (1)$$

Where  $d$  is the diffuse reflectance,  $s$  is specular gloss, and  $r$  is reflectance the ball. The range of  $d$  and  $r$  is  $[0.0, 1.0]$ . The value of  $s$  is 0 (matt) or 1 (gloss). A higher numerical value indicates more metal like. Degrees of metal likes of computer graphics images can be calculated as this function.

However, the degrees which based on rating scale method may dependent on subjectivity of observers. Then, we do Thurstone's paired comparison test with 20 images that are generated on selected parameters (five step of reflectance, two step of diffuse reflectance, and matt or gloss). 16 observers (males and females, ages 20-24) tool part in the test. As the result, we can determine the order of the degree of metal. The degree of metal is high when its parameters are high reflectance, low diffuse reflectance, and gloss.

## Proper-sized Thai letters suitable for elderlies and improvement of their visual performance.

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### Abstract

The ratio of population of elderlies to young people in Thailand is increasing rapidly and the country becomes elderlies society. Since most of the outside information is collected to us through the visual system, the proper infrastructure of the visual environment for elderlies is one of the important tasks of the country. The printed labels represent visual environment as they are the targets for getting information of the products. They have been found to be expressed by so small letters and are too difficult for elderlies to read.

A serious problem of the visual performance of the elderly comes from the cloudy crystalline lens of the cataract that scatters the incoming light all over the retina. It is considered that the scattered light makes the legibility of letters worse as the scattered foggy light lays over the retinal image of letters. The deterioration of the visual acuity investigated in the forgoing experiments should be because of the scattered light and cannot be avoided as far as the reading condition stays normal, that is the subjects read labels under illumination provided by ceiling light.

This research aims to investigate the visual acuity of printed small-sized Thai letters under various illumination conditions by using cataract experiencing goggles to simulate elderly eyes with cataract. The experiment is composed of two environment illumination systems; one-room and two-room. The latter aims to reduce the environment light to scatter in the eyes that make pattern recognition poor.

In the one-room system four illumination levels, 20, 80, 280 and 800 lx were assigned to resemble supermarket and household lighting condition. Three Thai fonts were examined.

In the two-room system the subject room and the test stimulus room were divided with a wall on which a window was opened for observation. Seven illumination levels, 0, 5, 20, 80, 280, 800, and 1500 lx were employed for subject's room while the test room was fixed at 280 lx.

In both cases subjects determined the minimum readable letter size. Test charts of varying letter sizes in positive contrast (white letters on black background) and negative contrast (black letters on white background) were presented to subjects for determining the 50% seeing threshold of correct reading.

For the one-room system the visual acuity improved with increasing illumination level, and it was lower with goggled eyes by about 0.4 at the illuminance 20 lx. Negative contrast fonts showed slightly better visual acuity than positive contrast fonts in all conditions. The 3 Thai fonts gave similar result in all conditions to show the insignificant font design factor on visual acuity compare to font size and illumination factors.

For the two-room system the visual acuity stayed more or less constant for all the illumination levels in both cases of the normal eyes and the goggled eyes. The visual acuity did not decrease with the goggled eyes compared to the normal eyes to show the advantage of using two rooms for elderly people.



## Physiological and psychological responses to color lights under environmental temperature change: focused on the comparison between normal subjects and subjects complaining of unusual coldness

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### Abstract

The purpose of this study was to investigate the physiological and psychological responses to color lights under normal and cold environmental conditions, focused on the comparison between normal subjects and subjects complaining of unusual coldness. Sixteen female subjects aged between 20 to 30 years old were divided into two groups as “normal” and “unusual coldness” by a 10-question interview. During the test, the subjects of each group were kept a sitting position respectively under white (x: 0.403, y: 0.448) and yellow (x: 0.470, y: 0.458) color light, dressed in gray (N6.5) sleeveless shirts and short pants. The exposure time for each subject was 20 minutes for normal condition (28.5°C, 30%RH) and 60 minutes for cold condition (23.5°C, 30%RH). The subjects' skin temperature, skin blood flow, rectal temperature, blood pressure and electrocardiogram were continuously measured. At the meantime, psychological questionnaires about subjects' impression of the color lights, mood, thermesthesia, cold discomfort during the test were conducted.

The physiological measure results indicated that under cold condition, reduced skin blood flow was recovered relatively faster under yellow color light than that under white color light. The fingertip skin temperature of “unusual coldness” group was lower than “normal” group under both color lights. The psychological test results showed differences among the impression by the 2 color lights in terms of “pleasant” and “warm and cool”. Meanwhile, subjects' mood and thermesthesia existed different responses to different environmental conditions or different color lights. Under cold condition, subjects of both groups felt “depression” and “discomfort”. And the rating scores of “depression” and “discomfort” were greater in “unusual coldness” group than in “normal” group. However, yellow color light deemed as warm color was considered decreasing the discomfort of cold in both groups. This study suggested color lights affect mood, thermesthesia and thermoregulation through cognitive process.

## Color choice: Product type, personal preferences and social norm

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### Abstract

According to many studies (Chu et al., 2011; Whitfield and Wiltshire, 1983), the desirability of colors is closely related to the product type (e.g., a car, a toaster or a table) and product style (e.g., modern or classic). Another study conducted by Holmes and Buchanan (1984) confirms that consumer's color choice often based on the product categories. Apart from product type and style, social influences and personal preferences also play a significant role in the process of color selection. Indeed, choosing colors for a specific object/product could be a complex interplay with many tangible and intangible factors. Paradoxically, consumers may not necessarily buy their favourite color (e.g., pink) if it looks "childish", "girlie" or "inappropriate" in particular life stage and/or social context (Creusen and Schoormans, 2005).

In order to gain a deeper understanding of what constitute consumers' mind when they make their color choice, semi-structured interview and visual stimuli were used to investigate the complex relationships among color, product type, consumer preferences and social influences. In total, 18 female informants ranged from 20 to 26 years old were recruited for this study. A clothing product (hoodie) was used as a vehicle to uncover and illuminate consumer's underlying motives of color choice during the selection and decision-making processes – including the congruency of self-image and product image; personal preferences and social norm; and color appropriateness and product type. According to the results of this study, it is evident that the colors of a product carry various learned and associative meanings within a specific consumption context. In many cases, colors do not only provide the psychological comfort to the users but also use as a signifier to manifest/express an individual's self. The overarching objectives of the present study are to generate practical and theoretical interest, identify research opportunities for the future, and offer insights and recommendations for fashion practitioners in general and designers in particular.

## **Analysis on the emotional reaction differences considering visual characteristics of normal-sighted persons and weak-sighted persons**

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### **Abstract**

In the 20th century, most designs did not reflect demands of various users because products were mass produced and had uniform designs. However, in the 21st century, as the new design to realize a welfare society, universal design, appeared and is being spread.

With such tendency, principles and guidelines for universal design are being studied more and more. However, still many designs only reflect planners' intentions. More efforts should be put to make plans that understand and care for weak-sighted users who stand in the most disadvantageous position. To achieve this, sentiment of the weak and differences of them compared to absolutely normal people should be grasped and understood.

Our eyes not only deliver original forms of objects, but they help us perceive social relations between me and objects from designs. Therefore, 'not seeing properly' becomes a great restriction to ordinary life.

Thus, in this study, following experiment was executed in order to identify differences in environment perception by normal-sighted persons and weak-sighted persons.

Total 20 images were produced and selected for evaluation to reflect visual characteristics of normal-sighted persons, color vision defectives (deuteranope and tritanope) and seniors. Among weak-sighted persons, those with dyschromatopsia who have many variables and difficulty in color perceptions and senior with xanthism were selected.

The spatial range of the test subjects is Seoul, the capital of Korea. Living spaces with natural and artificial elements were categorized to scenery of history, traditional residence, modern residence, city and nature. Images which expressed characteristics of each type were extracted.

Following methods were used to create characteristics of each visual type.

For sights of normal-sighted persons, selected images were used without any special measures. For sights of color vision defectives, images for normal-sighted persons were changed to reflect visual characteristics using a simulation program. For sights of seniors, lens filters to give yellowing effect were used to see images for normal-sighted persons.

The evaluation method was for test subjects to see prepared evaluation targets and to evaluate each evaluation vocabulary. 30 subjects participated in the experiments. They were accepted as color normal due to their previous record and experience in color evaluation. Such evaluation vocabulary included words that allow evaluation of capability. The rating scale was made in 7-step value evaluation method.

To analyze the experiment result, plot test was executed through descriptive statistics analysis and factor analysis for each evaluation vocabulary. This way, visual emotion of weak-sighted persons was objectively quantified to identify visual emotion differences with normal-sighted persons.

Through such studies, indiscriminative designs that allow same impressions and communications regardless of physical handicaps and that bring reasonable bond of sympathy with understanding and amalgamation will be created.

## Depth control algorithm using object color and depth characteristics

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### Abstract

3D displays, which have greater influence on visual information than 2D displays, are in the spotlight because they can deliver a higher sense of reality than 2D displays. The most serious problem of 3D displays, however, is the visual fatigue that they cause due to their excessive reproduction of the sense of three dimensions. This problem must be solved before 3D displays can become popular.

This visual fatigue, which is a major issue with 3D displays, is closely related to the sense of depth. The greater the sense of fatigue is, the more visual fatigue occurs. Although many methods of addressing visual fatigue in 3D displays and improving satisfaction with the sense of depth have been proposed, no methods of simultaneously reducing visual fatigue and improving satisfaction with the sense of depth have been proposed. One solution to the visual fatigue problem is to readjust the sense of depth of 3D images for lower visual fatigue; but although this method can decrease visual fatigue, the sense of depth via the human vision declines as the sense of depth cannot be adaptively controlled in tune with the characteristics of the inputted 3D images.

In this study, based on the theories of Livingstone and Hubel, the colors, shapes, motions, and depth that are used in the visual process in the brain were assumed as the basis for theoretical modeling that corresponds to selective visual attention. Among them, color information, which has great influence on human visual perception in static images, and sense of depth information, which is a differentiator of 3D displays, were selected as stimulants. Based on these two selected stimulants, color and the sense of depth, the effects of visual attention according to the perception factors of visual fatigue in a 3D image environment and the improvement of the sense of three dimensions were examined.

Furthermore, an algorithm for improving the perceptive sense of depth and reducing visual fatigue based on selective visual attention was developed to reproduce images that give a sense of depth and a sense of three dimensions while reducing visual fatigue.

## Study of an acceptable color-difference formula for printed documents on white paper

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### Abstract

The color difference  $\Delta E^*_{ab}$  (CIE 1976) in the uniform color space CIELAB does not always correspond to visual difference depending on colors. Various advanced color difference formulae based on  $\Delta E^*_{ab}$  have been proposed in order to achieve better agreement with visual impression. The CIE newly recommended the CIEDE2000 color-difference formula, which improved agreement between predicted color differences and their corresponding visual differences. The CIEDE2000 is recently used extensively. However, the CIEDE2000 was developed based on the color difference evaluations with a neutral gray background, Munsell N5. We may not be able to apply this formula to a color difference evaluation when a white plain paper was used as a background. Here, we examined the acceptability of color differences with white paper background by varying each of three color components: chroma, lightness and hue, in order to develop an acceptability color difference formula corresponding to the visual impression for the evaluation of printings on white paper.

For example, in the evaluation of varying chroma, we prepared standard samples and some samples which changed chroma at equal intervals for each standard sample. The size of samples was  $2 \times 2$  cm and was printed on a white paper by a printer (Kyocera TASKalfa 552ci). An observer was shown a series of samples placed in the chroma order and assessed how far color differences were acceptable. We also conducted the evaluation of varying lightness and hue in a similar way. Twenty observers participated.

As a result, we confirmed that the acceptability of the color difference in each of three color components had different tendencies. In the case of the evaluation of varying chroma, color difference tolerance increased according to the chroma value, which agreed with the fact that the weighting factors for chroma in the CIEDE2000 equation serves at chroma compression. In the case of the evaluation of varying lightness, the tolerance difference decreased with increasing lightness value. It is considered as the crispening effect due to the white paper background under our evaluation conditions. In the case of hue, the tolerance difference was almost constant among hue values. Finally, we deliver an acceptability color-difference formula which predicts the tendencies obtained from our evaluation.

## An augmented method of skin color on multi-primary display

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### **Abstract**

Human vision is extremely sensitive to skin colors. Based on previous researches, when people are looking at portraits, the key to judge image differences often depends on their skin colors. Recent years, with the increased use of displays, skin colors also play an important role in color reproduction. According to an article we presented in IDW'11 showed that skin colors were largely changed from monitor to monitor. Therefore, this research focuses on a method how we determine the presentation of skin colors on multi-primary display. Our proposed method is mainly divided into five study procedures. First, we use the software Photoshop to create about 1500 skin color chips with various colors covering possible skin color distributions. In order to identify the boundary of skin colors, we put the color chips on the CIE (x, y) chromaticity diagram and define a color gamut. Second, since there are principally 4 to 5 kinds of skin color groups in the world, we separate the skin color gamut into five regions and construct databases in each region. Third, we transfer the whole databases into multi-primary circumstance, using six-primary system. Then in order to see the color chip differences between original and multi-primary, we plot those data on CIE (x, y) chromaticity diagram again. Fourth, because an overflow-effect usually happens on chroma under multi-primary circumstance, we create a chroma fluctuation factor and set up a user interface by using an Eizo ColorEdge monitor to conduct pair comparison experiment with the original skin colors. Then, we decide a condition that skin color was represented the best. Finally, we assemble all fluctuation factors and build up a lookup table. Through reading some images containing with skin colors, we use the lookup table to obtain enhanced images. The results comparing with original images show that representations in the enhanced images were better than originals.



## Adaptive estimation method based on colorimetry for spectral recovery

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### Abstract

Spectral reflectance is an important property of a surface and, in most cases, has close relationship with the perception of colour. Extensive work has been carried out on spectral based colour reproduction systems require methods for estimating spectral information. In this context many learning-based algorithms have been proposed. The performance of most of the spectral-estimation methods is highly dependent on the training set. For example, Shen and Xin (2007) and Babaei *et al.* (2011) proposed methods to adaptively select training samples based on Wiener and Pseudo-Inverse (PI) estimation with a weighting factor determined by  $\Delta E^*_{ab}$ .

This paper proposes two modifications to the conventional estimation methods by selecting the localised training samples and introducing a weighting factor. In total, six methods were investigated including two conventional methods: Wiener and Pseudo-Inverse; and four modified methods: Wiener with localised set (Wiener\_Loc), PI with localised set (PI\_Loc), Wiener with localised set and weighting factors (Wiener\_wLoc) and PI with localised set and weighting factors (PI\_wLoc). The weighting factor and the localised set were determined by four measures,  $\Delta L^*$ ,  $\Delta C^*_{ab}$ ,  $\Delta H^*_{ab}$  and  $\Delta E^*_{ab}$ .

Two datasets were used in this study: 1562 glossy paint samples from the Munsell Book of Color and 1063 textile samples from the Professional Colour Communicator (PCC). The six methods were each applied to generate reflectance from a target colour with XYZ under D65/10° condition. The recovered reflectance was then examined using XYZ under A/10° condition. The performances were evaluated in terms of median CIEDE2000 colour difference ( $E_{00}$ ). Note, that for perfect agreement the predicted and the measured XYZ values should be zero.

In summary, the method using  $\Delta E^*_{ab}$  to obtain weighting factor performed the best, followed by  $\Delta H^*_{ab}$  performed marginally better than  $\Delta C^*_{ab}$ , and  $\Delta L^*$  the worst. Wiener\_wLoc and PI\_wLoc methods require fewer samples to achieve a stable performance than the Wiener\_Loc and PI\_Loc methods. If the same dataset used as both training and testing sets, the performance of the modified methods improved to approximately 0.5  $E_{00}$  unit from the conventional methods which gave around 1.5

$E_{00}$  units. If different datasets used to train and test models, there is a very similar performance between modified and conventional methods. However, there is a strong indication that the use of weighting factor determined by  $\Delta E^*_{ab}$  and localised dataset are particular effective when the number of training samples are less than 50.

## Colorimetry-free color management system applied to mobile phone displays

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### Abstract

Many of current color management systems (CMS) are designed to achieve colorimetric equality on different color devices. In metameric color matches, however, equal colorimetric values such as CIEXYZ tristimulus values assure equal color appearance only to the standard observer but not to each individual observer. Another and more serious problem of such CMSs is the effect of color adaptation to illuminants. Even though the spectral composition from the display is held constant, the color adaptation to illuminant may change the color appearance. Conversion of RGB values from one display to another must include the effect of color adaptation to illuminants for the exact same color appearance among different displays, observers, and illuminants.

In order to cope with such observer and illuminant variabilities, we have developed a new CMS based on color constancy phenomenon on reflecting surfaces. The goal of the CMS is to derive a 3-by-3 matrix to convert RGB values from one condition to another through visual color matches with reflecting color chips under the illuminants. Another advantage of the new CMS is a procedure where no colorimetric measurement is required since RGB values are converted directly but not via colorimetric values. This CMS consists of two phases of task. First, the display gammas are determined for each RGB channels by visual matches between a two-color checker stimulus and a uniform-color stimulus. The obtained gammas are specific to display, observer and illuminant and used to linearize RGB values. Second, reflecting color chips are subjectively matched with display colors by the observer. These procedures are repeated in different conditions (display, observer, illuminant) using the same set of color chips.

A conversion matrix between two conditions is calculated by applying a pseudo-inverse matrix to an equation consisting of pairs of linearized RGB values from color matches.

The new CMS was applied to mobile phone displays. In the experiment, a set of six Munsell color chips were matched with different mobile phone displays under the illuminant A and D65. The display RGB values of matches varied greatly with display, observer and illuminant. Then the color conversion matrices were derived from the matching results and the performance of the CMS were evaluated by color naming experiments.

## Imaging and rendering of human skin using an rgb color camera

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### Abstract

This paper proposes a method for precise rendering and color reproduction of a human skin based on multi-spectral reflection model and the reflection properties from imaging of the human skin surface. Firstly, we describe a reflection model for human skin based on an approximate model for subsurface scattering light reflection on the human skin as follows,

$$C(\lambda) = \left\{ \mathbf{N} \cdot \mathbf{L} + \frac{\mathbf{N} \cdot \mathbf{L} + l}{1+l} S_s(\lambda) \right\} S(\lambda) E(\lambda), \quad (1)$$

where  $C(\lambda)$  is color signal.  $S(\lambda)$  is surface spectral reflectance.  $S_s(\lambda)$  is color of subsurface on human skin,  $E(\lambda)$  is spectral distribution of light source.  $\mathbf{N}$  is surface normal of human skin.  $\mathbf{L}$  is lighting direction vector. The reflection properties are characterized by capturing the human skin images at each incident and viewing angles. These images are obtained using an RGB digital color camera. The spectral reflectance of the human skin is estimated from the RGB camera sensor outputs without camera sensitivity functions. The reflection intensity depends on the reflection model parameters. Therefore the problem of estimating the reflection model parameters can be solved as the fitting problem of refractive intensity on the skin surface at each incidence and viewing geometry.

Secondly, the surface normal vector representing a surface shape is estimated based on the photometric stereo method. Assume that the object surface reflectance can be described as Eq.(1). Then the surface normal vector is numerically estimated using images observed at three different illumination directions. In other words, the object shape is recovered from three images at different illumination directions. The surface normal vector  $\mathbf{N}$  is obtained from the least squared solution.



Fig. 1. CG image generated with the estimated parameters.

Finally, once we know all the rendering parameters, we can create precisely the computer graphics images using estimated parameters of the human skin. And also, we implement the proposed method to Graphics Processing Unit(GPU), supposing a color monitor as the display device for real-time rendering of the

human skin. Figure 1 shows computer graphics image generated with the estimated parameters.

## Preferred skin color of oriental women with different settings of correlated color temperature and luminance level on a display

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### Abstract

Skin color reproduction plays an important part in visual quality of a display's color reproduction. To find the colorimetric range of the preferred skin color on display is very important. For display color reproduction, the skin colors can be designed according to the preferred degrees of observers. However, most of the previous studies (Zeng et al. (2011), Beke et al. (2008), Tarczali et al. (2006)) of the preferred skin colors on displays only considered the specific condition. In the present study, two psychophysical experiments are conducted to determine the preferred skin color regions in terms of the correlated color temperatures (CCTs) and luminance levels on sRGB-gamut display.

Two kinds of experiments were designed in this study. In Experiment 1, the preferred chromaticity coordinates of the Oriental complexion were obtained. The skin color region of SOCS data (Standard Object Color Spectra database) under the settings of 4000 K ~ 25000 K was obtained by using CAT02 chromatic adaptation transformation. Then nine predetermined color centers uniformly sampled within the skin color ellipse in CIE  $a^*b^*$  plane (see Fig. 1) were determined to apply to skin colors of 4 test images. It is expected to find whether preferred skin colors are different when CCTs and luminance levels are changed on a LCD display. It was examined through the experiment under combinations of different CCTs (5000 K, 6500 K, 9300 K and 10000 K) and luminance levels (60 cd/m<sup>2</sup>, 100 cd/m<sup>2</sup> and 200 cd/m<sup>2</sup>).

Observers were asked to choose the best and the worst among the test images. Figure 2 shows the preferred results of each test image. It was found that E point, the average values of the skin colors extracted from the SOCS data, is the most preferred for all test images. It hints that the preferred degree of Oriental women's skin colors on a display is independent on CCTs and luminance levels.

In Experiment 2, a preference map of preferred skin color of Oriental woman on a sRGB-gamut display will be determined. The experiment will be carried out by using category judgment method. Sixty facial image candidates surrounding the color center (E point on  $a^*b^*$  plane) obtained in Experiment 1 were generated (see Fig. 3). To find the degrees of tolerance thresholds for the observer's judgments, the images will be chosen from the facial image candidates based on preferred skin-color designs to build the preferred color map. Observers will be asked to grade the degree of preference using a six-point category scale. Finally, the skin-color preference map showing the degrees of skin-color preference will be developed. The analytical results will be reported in the full paper.

## Color management for packaging, multicolor process printing methods in oman

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### Abstract

While many of the principles of package printing color management are, of course, the same as commercial printing, the nature of the substrate, the unique inks, and unusual color sets make it a much more complicated endeavor. Matching proofs spot colors that exceed a proofer's gamut, understanding the synergy of two inks on press as well as on a digital proofer, wondering if a coarse screen might affect viewing perception, and creating an acceptable system—both color management and proofing—for multicolor ink sets are all challenges a converter faces every day. If and when it is are ready to print packaging.

Proofing is more difficult with multicolor process printing. Making full use of the available color gamut on proofing devices is only one of the elements that will determine the accuracy of color matching. A color management system should be able to measure color—both CMYK and spot colors. However, it's the level of spot color handling that is the benchmark, particularly for packaging.

The specifications of Omani and some Arabic countries market are a specific that graphic designer are also a responsible about managing color, color correction, and most prepress modifications in order to prepare his file for printing. Color is one of the most important items of design and printing process. Packaging designers and printers must ask special questions when choosing hardware and software for press and prepress. There is a wide range of solutions available. One of the options worth considering is a standardized process based on ICC profile architecture. The ICC specification allows input, monitor, and printer profiles to be used with different color spaces. Profiles are most commonly used to convert data from RGB to L\*a\*b\* to CMYK. However, the specification also allows profiles to contain more than four-color channels. Thus, a six-channel ICC profile can deal with the situation of four process colors and two special colors. An ICC profile can have anywhere from 2 to 15 color channels. In conversation, these are referred to as “n-channel” or “multichannel” profiles, but in a profile, the precise number is listed—e.g., six-color, seven-color, eight-color, etc.

This paper is to put rules for packaging designer in order to color control package designs in some graphic software. The relationship between design on screen and final print will be basely studied to enhance the color translations result between different devices in the packaging reproduction workflow with Multicolor Process Printing MCPP.

## Improvement of organic screen printing ink for thai traditional fabric

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### **Abstract**

Green and healthy societies remain an important yet concerning issue in human life. It is generally agreed that the current tendency for new products is toward naturalism. Organic printing ink is one of alternative in the matter to prevent not only worker and consumer from illness, but also pollution from increasing. Although the organic printing inks are released, there is currently a severe lack of an organic ink for screen printing process served for Thai traditional fabric.

There are three stages in this study- ink making, printing process, and survey of conservative attitude. In the first stage, an organic screen printing ink was developed. The main ingredients were organic colorants, banana's latex, and tapioca starch. The organic colorants used in this experiment were extracted from India almond and mango leaf for green color, rosella for red color, curcuma powder for yellow color, and coffee powder for brown color. The ingredients were mixed in the proportion of one part of colorant solution to two part of banana's latex solution and were boiled at 100°C for 10 minutes. During boiling, the tapioca starch was added for control of a viscosity of ink at 11,180 centipoise. Two ink formulation, with and without nano-silver, were employed. The properties of inks, optical, physical, and end-use properties, were reported.

In the second stage, two organic inks were used for printing on the two types of Thai traditional fabrics, Thai cotton and Thai silk. A printing quality of them was investigated. Then, a Thai traditional image was printed out on the fabrics by screen printing process for making fabric lamps. These lamps were used for survey of conservative attitude. In the last stage, a conservative attitude obtained from preservationist or naturalism and general public is explored. We expect that our ink might be useful for printing out on the Thai fabric and could be representative as Thai tradition. Furthermore, our ink is one of the environmentally friendly products that preserve a world for the future.



## Goniometric multi-spectral imaging for digital archive using a multi-band camera

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### Abstract

In this study, we propose a method for digital archiving of an object based on multi-spectral reflection model and various reflection model parameters using both multi-band camera with optical filter and a device for measuring reflection intensity. In this study, we develop a simple spectral calibration method for multi-band camera system with statistical analysis of spectral reflectance. The feature of present paper is that the multi-band camera system is independent of camera sensitivity functions. Fig.1 shows diagram of the measuring system of goniometric multi-spectral reflectance. The device consists of a lighting system, goniometric rotating arms, and a vision system with two-shot 6 band digital camera. The image acquisition of the object surface is repeated for different illumination and viewing directions as shown in Fig.1.

Firstly, we develop a multi-spectral reflection model for describing object surface reflection based on the Torrance-Sparrow model. The color signal  $C(\lambda)$  is a function of the spatial location  $x$  and the wavelength  $\lambda$ , which is described as

$$C(\lambda) = \alpha \cos\theta_i S(\lambda) E(\lambda) + \beta \frac{F(n(\lambda), k(\lambda), \theta_H) D(\phi, \mu) G(\mathbf{N}, \mathbf{V}, \mathbf{L})}{\cos\theta_r} E(\lambda), \quad (1)$$

where  $\alpha$  and  $\beta$  are, respectively, diffuse and specular reflection coefficient.  $S(\lambda)$  is the spectral reflectance.  $E(\lambda)$  is the spectral distribution of illumination.  $\lambda$  is the wavelength. Function  $D$  is the roughness function.  $\mu$  is an index of surface roughness.  $G$  is a geometrical attenuation factor.  $F$  is the Fresnel reflectance.  $n(\lambda)$  and  $k(\lambda)$  are the

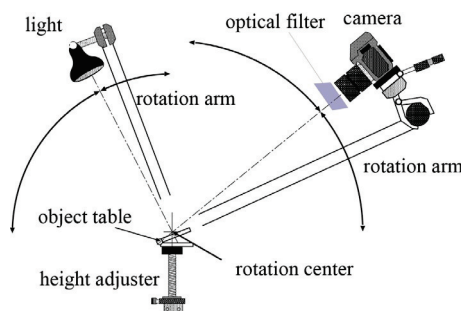


Fig. 1. Figure.1 Schematic diagram of the multi-band measuring system

index of refraction. Secondly, the reflection properties of an object are estimated from images using the device. In order to estimate multi-spectral reflectance of the object surface from camera outputs, spectral reflectance of the Macbeth color chart is statistically analyzed. To estimate spectral reflectance, multi-spectral sensitivity characteristics of the camera and the influence of illuminant are removed by the system conversion matrix. Thirdly, the reflection model parameters as the reflection properties are estimated from the camera measurements for reflection intensity of the object surface at different angles of illumination and viewing. Finally, we render a realistic image of the object and confirm the validity of the proposed method visually.

## The image quality index in consideration of the visual characteristics for a color noise

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### Abstract

It is important to know how people will recognize a noise in a color image. Although there are many digital cameras in recent years, it is difficult to distinguish the image quality between digital cameras. In order to compare the image quality between the images which the digital camera outputted, a suitable image quality index is required. The image quality indices which took into consideration the visual characteristics as SSIM or STSIM unlike SNR are proposed. Although these image quality indices are not reflecting the visual characteristics for a color noise, the image quality index to the image of a digital camera should take the visual characteristics of the noise into consideration.

We measured the visual characteristics for a color noise by subjective experiments, and we have studied the visual characteristics for a color noise. Here, the visual characteristics for a color noise mean the magnitude of the appearance of the added color noise according to background colors. The added color noise is a Gaussian noise which probability distributions distribute in the specific color direction in the  $a^*b^*$  plane centering on a background color. Therefore, the measured visual characteristics include background color dependency, the color direction dependency of a Gaussian noise, spatial frequency dependency (0.8-13 [cpd]), and luminance dependency. The color direction dependency of the Gaussian noise was gourd shape on the  $a^*b^*$  plane, when it expressed with the curve which a noise is perceived by equal intensity.

In this paper, we propose the novel image quality index for the images which degraded by the color noise using these visual characteristics. Since an image consists of an object and a texture, a suitable image quality index is not obtained only in the consciousness noise of a color noise. Therefore, we also take the adaptation effects for the spatial frequency of a local image into account to our image quality index. Our image quality index gives the evaluation value for the local domain of an image. We determine the local spatial frequency of an image using the DoG pyramids of each component in CIELAB space. The obtained spatial frequency is converted into absolute spatial frequency (cycles per degree) according to display resolution and viewing distance. We assume that the visual adaptation effects arise to this spatial frequency locally. We conduct the subjective experiments to the degradation image by a noise, and compare our image quality index and subjectivity evaluation experimental result. These experiments show the applicability of our image quality index. The experimental results also suggest the visual characteristics of affecting image quality. We discuss about what kind of the visual characteristic has affected image quality.

## Edge enhancement filter for the people with protanopic and deuteranopic vision

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### Abstract

This paper describes an image processing method to improve visibility of electronic documents and images for the people with color vision deficiencies, particularly protanopic and deuteranopic vision (red-green color blindness). The aim of the proposed method is to help color deficient people distinguish and separate out objects and texts from their background images.

The proposed method simply enhances the edges all over the image, so it needs not to examine color accessibilities (whether neighboring colors are distinguishable to color deficient people) before processing. The edge enhancement is implemented on the basis of unsharp-mask filtering (commonly called “unsharp masking”) that is the one of technique to sharpen photographic images.

This paper presents a modified version of unsharp masking. It can enhance edges of the neighboring colors that are inseparable and confusable for the people with color vision deficiencies. On the other hand, presented filtering makes moderate and practically unnoticeable enhancement of color edges for the people with normal (trichromatic) vision. Only edge colors of the objects are enhanced and colors in the other regions are almost stable, which is the reason why the edge enhancement is noticeable for color-defective vision and unnoticeable for normal (trichromatic) vision.

For protanopic vision, the proposed method enhances colors along M and S axes of LMS color space (represented by the response of the three types of cones of the human eye), by means of the addition of L value to M and S values. On the other hand, for deuteranopic vision, the proposed method enhances colors along L and S axes of LMS color space, by means of the addition of M value to L and S values.

One of example of the proposed method result is shown as below:

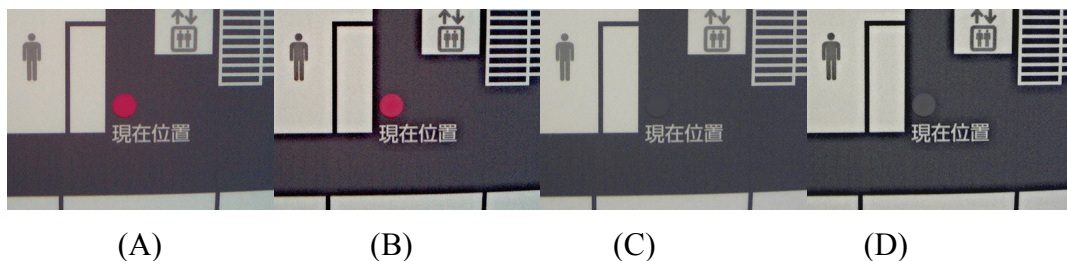


Fig.1 Proposed method can enhance a red circle in the black background: (A) Original image, (B) enhanced image by proposed method, (C) protanopic simulation image of A and (D) protanopic simulation image of B.

## Estimation of human skin properties using smartphone

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### Abstract

This paper describes a method for estimating the optical properties of human surface based on multi-spectral imaging using a smartphone camera in natural scenes. In this study, we use a smartphone as a color analytical device for human skin. The skin color is determined by the quantity of pigments such as melanin and hemoglobin.

In order to estimate the human skin condition, we estimate some properties of human skin such as melanin index and hemoglobin index from spectral reflectance of human skin. The absorption spectrum of the skin was calculated from the spectral reflectance of the human skin using a spectrophotometer. The original estimation method is proposed by Masuda[1]. We improved the method to suit for a camera as follows.

We propose a simplified method for estimating spectral reflectance using an RGB color camera without camera sensitivity function information. We assumed that the spectral reflectance of a human skin surface can be described as linear combination of some basis functions. The system conversion matrix from the camera output to spectral reflection is estimated using color chart and spectrophotometer. In order to estimate multi-spectral reflectance of the human skin surface from an uncalibrated camera (smartphone's camera) outputs, we make the conversion matrix from the uncalibrated camera RGB color space to the calibrated camera RGB color space. To estimate spectral reflectance, the camera device characteristics and the influence of illuminant are removed from the camera outputs.

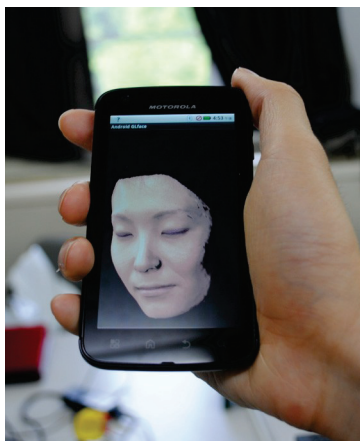


Fig. 1 Rendering result on smartphone

Thirdly, the melanin index and the hemoglobin index are estimated from the absorption properties of the spectral reflectance from the camera output. The total estimation method is implemented to the smartphone. Finally, we implement the reflection model of human skin to Graphics Processing Unit (GPU) of smartphone. And also, we propose an implementation method of reflection model to Android GPU architecture. We render a realistic image of human skin using the estimated skin properties on smartphone and confirm the validity of the proposed method visually. Fig.1. shows rendering result on the smartphone.

## Color conversion in a tolerance quadrilateral for energy saving

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### Abstract

In recent years, different color temperature is used in different environment or different demand of users, and color temperature conversion is applied in many fields just like lighting, color displays, photography, and many other fields. In the present, the color conversion does not mention very much about how to achieve maximal luminance. In the previous literature, when we adjust the white point of device to the target color temperature, we have many choices on the isotherm line. One method to find the maximal luminance on the isotherm line is that the point is intersected by the isotherm line of the target color temperature and the line of gravity-center of the triprimary color triangle.

Moreover, according to specifications for the Chromaticity of Solid State Lighting Products in 2008, that proposed by American National Standards Institute (ANSI), a tolerance area of color temperature is proposed for lighting product variation. The tolerance of the target isotherm line obtains two isotherm lines, and the width of  $D_{uv}$  tolerance is  $\pm 0.006$ . The tolerance area is a quadrilateral linked by these four lines. In other words, the quadrilateral is the tolerance range of the target color temperature. From the view point of the color gamut volume, the maximal luminance point of the color volume is the white point of device. When the luminance reduces, the apexes of color gamut boundary expand along the three lines of gravity-center. Therefore, the color gamut boundary expands outward as the luminance reducing. So, when the apex of the color gamut boundary first meets the point of intersection between the line of gravity-center and the quadrilateral defined by ANSI, this point is the maximal luminance solution of color temperature conversion. This method can gain more energy than the former method, and also can be applied in energy saving of LED lighting and display.

## Estimation and simulation of spectral reflectance based on subtractive color mixing

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### Abstract

The purpose of this study was to establish a new model to estimate the spectral reflectance of objects captured directly in an images under a certain illuminant. The spectral reflectance is simply composed of a linear combination of the basic spectrums of C, M, Y, and the neutral color according to Macbeth color checker, named as spectral absorptive bases of objects.

These bases are regarded as the core to represent the absorptive property of objects, and are derived with the principle of subtractive color mixing and metamerism. This spectral reflectance estimated is the optimal one with least error in terms of the difference measure in CIE XYZ color space. Accordingly, the objects captured in an image can be re-rendered as which it were be under another illuminant with low calculation. The estimated spectral reflectance we proposed; moreover, can be used for various applications, e.g. post-production, automatic white balance, digital lighting.

In our method, the spectral reflectance of objects is defined as the linear combination of spectral absorptive bases of four colors. The combination coefficients are simply represented in terms of the four channel values obtained from an image in sRGB space without the required of complicate computation; therefore, all we need to do for the spectral estimation is to transform the R, G ,and B into the spectral absorptive bases. Furthermore, the equations of tristimulus values were used to acquire these bases by solving the simple linear system formed with four channel values under a specific illuminant, say virtual daylight 6500K. Finally, the spectral reflectance of an object demonstrated by a pixel in an image can be directly computed from four channel values of this pixel and the spectral absorptive bases derived.

Some experiments will be performed to evaluate the accuracy of the estimated spectral reflectance of objects using CIEDE2000 and the MSE (Mean Square Error). In brief, this study represents a new type of estimation method for spectral reflectance of objects captured in an image. And, its computational cost is low and suitable for many practical applications in real time.



## An effective training of neural networks for categorical color perception

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### Abstract

Humans often use color information in everyday communications. We can distinguish subtle differences between several similar colors. On the other hand, we use rough color category such as red or blue when we tell a color to others. This is categorical color perception that is used in the latter case. On the other hand, an object color is not only exclusively distinguish by the reflection spectrum from the surface object is but also greatly influenced by the ambient environmental conditions. We humans, however, can stably perceive an inherent an object color even reflection spectrum from the object changes according to spectrum of ambient light. This is called color constancy. The categorical color appears the influence of surrounding environment with color constancy. Therefore the automatic color recognition technology which can correctly discriminate a categorical color under various environments is required. The purpose of this study is to get the model that can operate similarly to human categorical color perception and color constancy. It is related to a categorical color perception system for automatically discriminating a categorical color. And it is a technology for correctly color recognition under various environments.

The authors provided a categorical color perception system which is capable to realize it. The relationship between the chromaticity of color chips under different illuminations and human categorical color perception for the color chips under the illumination has been learned using a structured neural network. The trained network can determine a color-name of objects from images. In this previous research, the training data is the product of a categorical color naming experiment. The number of training data is however skewed in each category. For this reason, the model is inaccurate for several categories. The model cannot be applied to natural scene images which require a high accuracy. In this paper, we propose a new model with averaging the amount of training data. In addition, we evaluate the model performance using images taken in various illuminants conditions. As a result, we show that the categorical color recognition by the proposal model was increased accuracy.

## Development of a skin analysis system based on the 3D facial avatar

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### **Abstract**

As presented in this paper, we described the development of a skin analysis system based on the 3D facial avatar. The commercial skin analysis system was developed. That system typically uses a 2D image for the skin analysis and consist of a digital camera and several light sources such as white flash light, UV-A flash light(365 nm UV light) and polarized light. Their biggest concern is how to obtain the high-resolution 2D images to provide fine image of skin to user. But our main concern is how to increase reality. So we was developed advanced skin analysis system that can generate a 3D face model. Our system consist of stereo cameras to reconstruct 3D facial avatar and several LED type light sources. Our system uses two or more images to create the geometric model and provide three kinds of 3D model textures under different light sources such as general light, UV light and polarized light. This system very easily can generate a 3D facial model using only 2 images. This system very easily can generate a 3D facial model using only 2 images and can generate 3D model texture for the analysis of skin. The 3D model texture under general light is used to analyze skin color and tone. The 3D model texture under UV light is used to analyze pore state, hydration of the skin, excessive pigmentation and keratinization. The 3D model texture under parallel polarized light is suitable for observing the epidermis and surface of the skin. To provide real skin color, digital device characterization techniques were applied in our system. Our system supports ICC profile in order to provide a characterized 3D model texture. In addition, the LUT(Look-Up Table) has been used for fast transform the color of a 3D model texture. So this system allows for more realistic skin analysis, and should reproduce the actual color of the skin.

## Colours of architectural metal surfaces

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### **Abstract**

Contemporary buildings interact with human beings mainly through their surface. In our times, architectural surfaces can be made from many materials. Among these, metallic materials seem to play a very important role.

Used for a very long time for their expressive features – for example, you may think about the golden domes of Russia or the Middle East – they are now among the most common materials in the manufacture of items and surfaces for architecture. Today's techniques of production, with their infinite capacity to create new devices, they are able to propose metallic materials with color and surface characteristics always new.

A research recently conducted by the "Colour and Light" Research Unit of Iuav University of Venice, after classifying these materials and their color, has tried to frame the types of stage effects that metal surfaces are capable of producing. We used the old color theories of Johannes Itten integrating them with more recent studies such as those made by the architect Attilio Marcolli or the designer Jorrit Tornquist. This showed an overview which identifies three types of effects that seem to be sought after by the designers, through the use of these materials. 1) The metallic color can be used to impress and stun the observer. 2) The metallic color can be used to dematerialize the mass of the building, to reduce its presence in the context. 3) The metallic color can be used to create harmonious relationships with the environment through the use of color contrasts or color agreements.

The paper aims to describe the methodology we have used and the results we have obtained, with particular attention to the cultural references taken into consideration for the identification of the research parameters. The ultimate goal of the paper is to describe the three different color effects produced by the metal surfaces by drawing on a sample of metal-buildings constructed in the last three years.

## **A study of the relationship between urban colour and public art - Exemplified by the treasure hill environmental color**

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### **Abstract**

Public art, which integrates visual art into space and environment, has become an international trend over the past twenty to thirty years. In 1992, Taiwan had its first own official policy for funding public art and in 1998, Taiwan announced its schemes of installing public art on selected sites. Besides serving as a platform for artists, public art is also a means to uplift the life quality in public spaces and promote art education for all. For decades, the government has continued to increase its funding for public art which has now developed a diversity of forms and styles. The current public art policy in Taiwan has further accepted into its public art domain non-material and event-based interventions.

Visual sense is The public's main source of environmental experience is a visual sense, where colors serve to enhance objects and create certain atmosphere. Colors, placed in certain environments, can have a great impact on people's perception and behavior. Taiwan, with its commitment to public art development, has begun to explore facets of its cities by color-related schemes. Though the government included and emphasized "Urban Color Schemes" in its civic aesthetic policy of 2009, there hasn't been much progress in planning and executing of the scheme. Neither is there any light on the decision of color-choices in public spaces and on the manner of using colors to harmonize outdoor space.

To make a comprehensive survey on the environmental and space quality in Taiwan, colors place an important role in environmental disorder and incoherence. With the increasing number of public art projects, no one seems to have investigated the effects colors used in public art have on their surroundings and no relevant publication has yet been made available. On the whole, Taiwanese citizens along with decision-makers and professional designers should have sound knowledge and understanding of colors and their usage.

This research aims to investigate current resources and references to Taiwan's public art. In addition, based on the public art and its color relative to the surrounding areas in the Treasure Hill, this project intends to launch a color survey in Treasure Hill and its adjacent Gongguan shopping zone. Through collecting, investigating, and representing the colors in the environment of the development plan in Gongguan, it is expected to provide an environment color study, both natural and artificial, for the studied area. Meanwhile, the research project would further study the color combinations between the color of public art and that of the environment as well as its influence on the local public, which can be a reference and application for assessing public art in public sites and constructions in the future.

## Investigation on Chinese colour naming by college students

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### **Abstract**

Colour naming depends on factors such as language, age, gender, nation, culture background, colour preference and so on. The purpose of this investigation is to attempt to understand the relationship between the colour naming and the above mentioned factors. In the experiment, four colour series, i.e., pink, blue, orange and cyan, in which each colour has a known English name, were selected. 66 Chinese college students were asked to name those colours in the four series in Chinese. The results indicated that: (1) Some colours were failed to be given Chinese names, the percentages of successfully named colours in four series were respectively 82.9% (pink), 85.9% (blue), 83.3% (orange) and 66.3% (cyan). (2) The percentages of colours with the same name in four series were respectively 24.5% (pink), 30.1% (blue), 17.6% (orange) and 19.7% (cyan). (3) Colour preference and association. (4) Similarities and differences between English and Chinese colour naming: generally, both in English and Chinese, colour names are associated with plants, minerals, materials and natural scenes, but animal colours such as fish colour etc. are rarely used in Chinese names.

## Models of architectural mimicry

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### Abstract

In nature we often find mimicry – the similarity of one species to another. For example, yellow stripes on the bodies of some flies make them look like wasps; many species of non-venomous snakes resemble the deadly coral snake or rattlesnake, etc. As a rule, the appearance has a defensive function: a harmless animal poses as harmful and thus saves its life. There is a similar phenomenon in the social sphere – social mimicry, a protective adaptation of individuals by following the group in their behavior and thinking.

The model of social mimicry structurally has a resemblance to natural mimicry. It comprises three main elements: a prototype object, an imitator object and an operator (an individual, small or large social groups).

One should distinguish between chromatic and morphologic mimics. Chromatic mimicry (homochromism) is a color similarity of architectural objects to the other constructions or objects. Morphologic mimicry (homomorphism) implies not only color but also morphologic resemblance of an architectural object to the environment.

As a result of the variety of prototype objects social mimicry in architecture falls into several types: camouflage, vernacular, stylistic, and functional mimicry.

In the case of camouflage mimicry the imitator copies the form (camouflage homomorphism) or the color (camouflage homochromism) of the existing natural environment.

Unlike camouflage mimicry, vernacular (from Latin *vernaculus* – “domestic, native”) mimicry doesn’t imitate the form (vernacular homomorphism) or the color (vernacular homochromism) of the natural objects, but the products of a certain culture. This type of mimicry presents an attempt to “build in” a construction in the actual architectural context by adding to it some specific elements of the culture.

Stylistic mimicry is an imitation of architectural forms of a certain epoch or style. Stylistic mimicry always has a time vector. As a model for the imitation there may be chosen a form, that has been already experienced in architecture, or a new undeveloped form. Therefore stylistic mimicry may be retrospective or prospective.

Functional mimicry stands for masking of some existing construction under the influence of the social environment. Functional mimicry usually spreads intensively at turning points of history.

According to the contemporary biological theories phenotypes of prototypes and imitators in nature react to each other differently. As well we find different strategies of such interaction in architecture. In the case of camouflage mimicry prototypes are the natural objects (sky, water, trees, ground), in the case of vernacular mimicry – the products of culture, that do not react to their imitators. Functional mimicry is characterized by such an interaction, when the prototype and the imitator present a model for each other and become alike in the course of the evolution. The third variant of interaction is purely parasitic: an unadapted organism imitates a socially adjusted model.



## Preferable LED lamps for appearance of skin color of human face

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### Abstract

Recently, LED lamps have been installed in many buildings such as houses, restaurants and stores. The appearance of a human face in these buildings depends on the property of the LED lamps, color temperature and spectral distribution and so on.

This study aims to determine the preferable LED lamps for the appearance of skin color of human face. We conducted two subjective experiments on the appearance of the skin color under some lighting conditions using head mannequins.

In the first experiment, we made the experimental apparatus composed of 2 boxes which could equip lighting on the ceiling of each. We prepared 9 kinds of LED lamps which differed in correlated color temperature (CCT), general color rendering index (CRI), and the distance from the blackbody curve for the color temperature (Duv), halogen lamp and D<sub>65</sub> lamp. We also prepared two female head mannequins which was put on makeup (forehead; 7YR 7.25/4, cheek; 7YR 8/4). Firstly, subjects observed one head mannequin in the left box under a lighting condition. Next, they observed the other in the right box under another lighting condition, and evaluated the preference of skin color of the head mannequin compared to the appearance of the left one with Scheffe's method of paired comparison, according to the 7 steps of verbal scale, 'very good', 'good', 'somewhat good', 'same', 'somewhat bad', 'bad', and 'very bad', under the lighting conditions of 15 pairs of different lamps.

In the second experiment, subjects evaluated the impression of the face of the head mannequin in terms of "skin tone", "complexion", "sophistication", "health", "activity" and "familiarity", and also rated "preference" as a comprehensive evaluation, according to 7 steps of numerical scale from 1 (which meant bad) to 7 (which meant good) under 11 lighting conditions. Subjects in these experiments were 10 females, university students in their twenties.

As a result of the first experiment, it was shown that the preference of the skin color of the human face under any kinds of the 3000K LED lamps was better than that under the halogen lamps, and that the preference under any kinds of the 5000K LED lamps was better than that under the D<sub>65</sub> lamp. It was also shown that the 5000K LED lamp which had high CRI value and low Duv value was preferred to other 5000K LED lamps.

As a result of the second experiment, it was indicated that the preference of the skin color of the human face was determined primarily by the "familiarity", and it was also determined by the "sophistication" and the "health".

## Sensitivity evaluation based on the color distribution of commercial buildings and media facades type

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### **Abstract**

Cities have used the pedestrian passages, signboards of the buildings, banners and so on to convey what they want to deliver. Thanks to the development of digital media together with the ubiquitous technologies, the present communication of information has started to take the shape of media facades. In order to perform the basic function of the building elevation to communicate with the people beyond the simple conveyance of commercial information, the development in this area has been made focusing on the display of the artistic and emotional contents. With the media facades, the regional characteristics and the experience of spaces don't appear seamlessly even in the night. At this stage that the night views of the cities are changing actively by the new applications of media facades, it is necessary to introduce guidelines fitting to the characteristics of the cities. In other words, it is required to suggest some guidelines for the digital colors suitable to the consumption patterns or the types of sensitivity of the residents or the visitors which can be acquired by investigating the characteristics of the city cultures formed based on the commercial consumption cultures.

In this study, the types and chromaticity of the media facades of the buildings in downtown are researched and analyzed, according to the location of the constructions and their commercial uses. Through the study on the color distribution changing by the commercial uses and the regional characteristics, the regional cultures and the behavioral patterns of consumption cultures could be considered as the main factors for this study.

The methods of study are as follows: First, the characteristics of media facades which had been limited to the area of lighting were examined to be classified into three types. Based on the type classification, 10 regional cases were selected. Second, the cases of media facades were taken by the digital camera and their brightness and chromaticity coordinates were measured and analyzed, using the color brightness photometer CS-100. The color difference, chromaticity and brightness were measured by the consecutive measurement in the unit of one second, according to the pattern and the change of chromaticity for each case. Third, the measured digital colors quantitatively were extracted and analyzed by the CIE x and y diagram for the chromaticity and the values for the chromaticity. Forth, the analyzed values of the color coordinate changed to CIE RGB to see the arrangement of color distribution according to the sensitivity measurement coordinates. The color coordinate showed the emotional tendencies according to the consumption cultures. The results can be used as the basic investigation in developing the digital sensitivity color schema based on the regional cultures in the future.

## Towards new ambiances of 'light-material-colour' in urban space

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### Abstract

Subtly our cities have moved from being 'colourful' places to become spaces of whiteness, transparency, brightness and glare. Shadow is conspicuously absent and the rough textures of materials have been replaced by a tedious, abstract smoothness where any visual and tactile sense of materials no longer exists. Instead urban space has become a dazzle of light and colour: architectural forms and the cityscape as a whole glint, shimmer and sparkle twenty-four hours a day erasing the natural day and night cycle. A multiplicity of projection screens and enormous lit displays permanently clad exterior and interior spaces upon which collective and individual movement of living beings and things are performed. These unending images dissolve the actual presence of real public and private spaces of everyday life and reduce the appearance of colour to those belonging only to a virtual and ephemeral world.

In short, colour as understood and applied in a traditional way is no longer considered as a vital, physical element of urban space. While this loss be mourned and criticised, as described above, still there are also new potentials, especially in the replacement of traditional pigments and authentic materials with flexible, interactive materials. Smart and intelligent materials can adapt their light transmitting properties and chromatic appearance in response to human sight, touch, temperature and sound. Hybrid electrochromic devices and materials make it possible to create different states, which can be, e.g. transparent, translucent, mirror-like or coloured. The poignant visual effects of smart glass, methacrylates and other sophisticated materials (still being developed) can be easily adapted to individual needs and desires creating exclusive atmospheres and artificial colour-and-sound ambiances. Structural colour caused by interference effects is a main property of contemporary materials, e.g., iridescence permanently changes the chromatic appearance of materials, objects and buildings according to dynamic light and controlled environmental conditions. Such applications require the establishment of new colour codes as a new colour vocabulary, new colour practice and new colour culture emerge.

Today we are in a time of transition in which traditional materials, e.g., stone, brick, etc., have achieved a kind of timelessness and perfection due to long-term application practices, while new ones are meant for immediate use and intended to be continuously replaced and with great speed. Combining these heterogeneous materials with their different durability, colour and texture appearance is one of the most complex tasks architects, urban designers, colour consultants and landscape architects are being confronted with in achieving newly conceived but harmonious urban spaces.

The philosophical approach of this paper will be underscored by specific examples of materials and urban spaces.

## Examination of a suitable lighting for a nap in a resting room of an office

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### Abstract

It is known that one fifth of Japanese people have some difficulty in sleeping, that is, it is doubted that they have a sleep disorder. The influence of a room light can be one cause for the disorder. The relationship between the lighting and sleep has been studied (e.g. Czeisler et al., 2012). However, many of those studies examined sleep at night. Sleep at daytime, that is the “nap,” has not been extensively studied previously. In recent studies, naps begin to attract attentions. It has effects of the recovery from fatigue, stress reduction, and improvement of performance in the work. In this study, we investigated the chromaticity and the illuminance of a suitable lighting for a nap in a resting room of an office, because the room generally cannot be completely darkened.

We tested eight kinds of lightings; incandescent lamps, broadband white LEDs, a white lighting made by RGB LEDs, a yellow lighting by RG LEDs, blue LEDs, green LEDs, orange LEDs, and red LEDs. There were three illuminance conditions for the broadband white lighting; 50, 100, and 200 lx. The illuminances of the other lighting were fixed at 100 lx. The blue, green, orange, and red LED conditions were added by supplemental fluorescent lights filtered by the same colour as the LED lights in order to obtain the illuminance of 100 lx. We measured subjective sleepiness before and after the exposure of these lightings and examined impressions for these lightings. We especially focused on a suitable lighting for a nap, although Inoue (2010) has reported impressions for various coloured lightings. Nine volunteers participated in the experiment.

The results showed that the red light and the blue light inhibited subjective sleepiness. Moreover, the evaluation of the impressions for the red lighting was very low. On the other hand, the orange light and the incandescent light not only promoted subjective sleepiness but also provided a good emotional evaluation. These results indicate that the red light and the blue light are unsuitable, and that the incandescent light and the orange light are thought to be suitable at least psychologically for using in a resting room that is for taking a nap. It is necessary to confirm these suggestions by physiological evidence in the future work.

## Colorful world, wonderful life - application research on color of residence landscape

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### Abstract

1. About residence landscape
  - 1.1 Definition of residence landscape, its position in landscape and current status
  - 1.2 Significance and value of color in residence landscape.
2. Color statue of international residence landscape
3. Color statue of Chinese residence landscape
4. Application of residence landscape color
  - 4.1. Color of residential buildings
    - 4.1.1 The core of color planning is to satisfy the requirement of unifying the style, being plain and building comfortable atmosphere.
    - 4.1.2 The function of color in residential buildings is to satisfy people's physical and mental requirements.
  - 4.2. Color of hard pavement
    - 4.2.1 Regional color expression
    - 4.2.2 Pavement color planning in different functional places
    - 4.2.3 Rule of color coordination in residential landscape
  - 4.3. Color of landscape sketch
    - 4.3.1 Indicative sketch
    - 4.3.2 Functional sketch
    - 4.3.3 Color of sketch in different functional areas
  - 4.4. Plants
    - 4.4.1 Color coordination for plants in four seasons-----Considering long-term effect
    - 4.4.2 Color coordination for plants in one season-----Considering short-term effect
    - 4.4.3 Ways of color coordination
  - 4.5. Lighting
    - 4.5.1 Overall principle: Making the lighting of exterior areas an organic body
    - 4.5.2 Functional principle: Considering functions of the lighting of exterior residential areas
  - 4.6. Waterscape
    - 4.6.1 Bottom color of a waterscape
    - 4.6.2 Attempering effect and influence of color in the view of water reflection
    - 4.6.3 Attempering effect and influence of the lighting reflection at night

## How does street light affect our psychological impressions?

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### **Abstract**

There are many lights on the street at night: street lights, security lights, electronic signage and light from the office buildings and houses. This study focused on street lights, which have a strong influence on our psychological impressions and behaviors at night. Recently, new lighting technologies such as light emitting diodes (LEDs) have started to be used for street lights. These technologies would enable us to design new street lighting systems more flexibly in terms of spatial arrangement and they also allow us to use more colors for street lights. The results of the study would give a method for planning street lighting systems based on our perception.

In this study, we focused on how the lighting environment would influence our psychological impressions at night. We carried out a subjective assessment using photos of street scenes at night in residential and commercial areas. In this experiment, subjects assessed their visual impressions of street scenes. Subjects observed the 62 pictures projected on the screen in random order. They gave scores for 7 evaluation items relevant to a street at night, "Clear", "Bright", "Active", "Glaring", "Comfortable", "Safe", and "Like" with 6 steps on a categorical scale. It was shown that the assessments were rated higher where there are more light sources on a street and bright areas of street surface. In addition, luminance of the whole street scenes affected the assessments. Therefore, it was shown that the brightness of the street surface, as well as luminance of the whole scenes affected our impressions on the street at night.



## Color Tones of Cityscape based on a Comparison of Seoul Regional Cultures

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### Abstract

Seoul City has successfully emphasized the value of city brand enough to attract the attention of the world; with the result that Seoul was selected as the 3<sup>rd</sup> best city for the world's people to visit in 2010. Seoul deserves to become a place with variegated landscape capturing public attention thanks to its history, location and environmental characteristics. Now the sceneries in Seoul worthy of the name gave become tangled like nets with historic settings such as the palaces and the Korean-style house roads that have been formed for a long time, the main streets encompassing up-to-date IT technologies, or the re-designed streets with the arranged signage. If the sections showing the strong contrasts are placed in a parallel row, we may be able to see the dramatic varieties that do not seem to come from a city. This study is to investigate the color harmony schemes of two areas in Seoul which are recommended as the streets for tour courses. The first one is the Gahoedong street of the northern village where the high-ranking officials and the royal families used to reside in the old days. And the second one is the Gangnam broad street from the Gangnam subway station to the Kyobo Tower intersection.

For the purposes of this study, the surrounding sceneries of the two selected streets were photographed first. A digital camera (Canon G10 30.5mm) was used for the photographing from 10 a.m. to 3 p.m., when the surrounding buildings are in harmony with the environment on the basis of the townscape color. Secondly, the photos mainly taken for the places where the color harmony schemes of the areas are well characterized and properly taken in the aspect of colors seen with the naked eye and in the visual colorimetric analysis were classified by area and by location.

This classification is usually made by the researcher's analysis because the cityscapes are naturally accepted and recognized by the naked eye. Thirdly, the color harmony scheme was analyzed using the NCS color coordinates after the color frequency of the classified photos was investigated using the Pixelate of Adobe Photoshop filter. In this study, the color scheme was limited to five kinds of colors after analyzing the distribution of pixels. And the colors of the sky and the natural landscapes without the buildings were excluded in analyzing the color schemes based on the frequency of color distribution. The derived representative color scheme was expressed in NCS color coordinates and the RGB colors and analyzed by the tones based on the NCS nuance and the distribution of color system.

As a result of this study, it can be said that the characteristics of the areas come from the landscapes and the contrast in color schemes of the two areas may be used for the analysis of the regional cultures, lives, and even the tendencies of the people in the business district.

## Exploring the influence of the landmark public art on the neighborhood environment - Take an Example of the Public Art on the Exterior Wall in Shuiyuan Market

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### **Abstract**

Public arts contribute to the improvement of municipal space and increase the opportunities of exposing citizens to the arts. In recent years, the government has been inviting skilled artists to work on the old buildings and gave them new looks by the means of public arts. Since 2006, Taipei Municipality Government has carried out the program of Taipei Beautiful, planning urban renewal and establishing urban features. Public Art Exhibition Series Eight focuses on the integrity of the building landscapes in Taipei city, enhancing city attractiveness and the aesthetic accomplishment of the people, establishing district landmarks and reshaping the exterior appearance of the buildings. One example is that the internationally renowned artist Mr. Yaacov Agam (1928~) was invited to renovate the exterior wall of Shuiyuan market with his unique innovative style (The interaction between the artwork and the audience, as the viewing angle changes, the artwork changes too), reshaping the landmark buildings in Gongguan business center.

As a landmark building of the public art in Gongguan business center, Shuiyuan Market has attracted the attention because of the interaction between the artworks and the angles of viewing, the images change as the viewing angles change, furthermore, the bright tones and the contrast between the large-area color and the surrounding environment gave rise to discussion, which also gradually led to the color change of the surrounding environment.

This study object is the public art on the exterior wall in Shuiyuan market since its establishment in 2010 up to now, exploring the impact of the tones of the public art on that of the surrounding business center. There are five parts in this study: First, developing research project and procedures; second, collecting and analyzing the street history of Gongguan business center and Shuiyuan market, then analyzing the public art in Shuiyuan market, including the interview with Taipei City Government on the planning of this area, analysis of the arts of Mr. Yaacov Agam and his concept about the public art in Shuiyuan market. The third part resulted from the field observation (including photos and drawings) since 2010, analyzing the colors in the surrounding areas of the Shuiyuan market with the public art. The fourth part worked on the collected information and further discussed the impact of the landmark public art on the surrounding environment. The fifth part is the conclusion of the study. It also provided consequent suggestions to the study object.

## An analysis of Urazaishiki (reverse coloring) used in Japanese paintings by Itō Jakuchū applying gonio-photometric spectral imaging

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### Abstract

Itō Jakuchū (1716-1800) is a Japanese painter, well known for his works titled “Dōshoku Sai-e” (E. Colorful Realm of Living Beings; c.1757-1766), a set of 30 hanging scrolls, which is one of the nation’s cultural treasures. In 2011, NHK (Japan Broadcasting Corporation), made a project to record high-definition images of the 30 scrolls and examined the technical means by which Jakuchū created each scroll. We were requested by NHK to apply scientific analysis of “Urazaishiki” (reverse coloring), one of the coloration techniques used in Dōshoku Sai-e. Urazaishiki is a technique in which color is applied from the reverse side of the silk cloth for painting. Because of the translucent characteristic of silk, a combination of reverse and front side painting creates various optical effects.

In Kōyō Shōkin-zu (Birds and Autumn Maples; c.1766), one of the scrolls, Urazaishiki is applied in most of the autumn colored maple leaves, creating different grades of opacity and transparency. In order to measure the effect of Urazaishiki, two sample images of an autumn maple leaf, with and without application of Urazaishiki, were created for our experiment. For both maple leaves, their center parts were colored with yellow and their peripherals with red. For the Urazaishiki sample, yellow pigment was painted on the reverse side of the silk cloth, while for the non-Urazaishiki sample, the yellow pigment was painted on the front side.

These leaves were measured by a gonio-photometric spectral imaging system composed of a white LED illuminant, a liquid crystalline tunable filter, and a CCD of monochrome imaging device with Peltier cooler. The system brought us accurate data of spectral reflectance factor at each pixel of the image. Each sample was illuminated from the direction of 45° and 75° with respect to the sample normal, and the reflected flux was detected in the direction of the sample normal.

The Urazaishiki sample indicated a higher reflectance factor compared to the non-Urazaishiki sample for either angle, the reason of which would be the following. For the Urazaishiki sample, the spectral response at each pixel of the center part of the leaf consisted of both unique gloss pattern due to the silk substrate and selected spectral profile due to the absorption of light by the pigment. Summarizing the results, it was found that Urazaishiki shows various visual effects depending on optical condition of illumination and observer, whereas non-Urazaishiki shows rather simple visual effect.

## Textile re-design

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### Abstract

- The present days and the signs of the past.
- Quotes, revivals and reinterpretations.
- The Russian agitational textiles.
- Color palette, real (true / effective) and imaginary.
- The exhibition: Textile Re-Design.

This work (project?) intends to present the projects done by the young designers of the "Digital Textile Design" course at AFOL Milan-Moda, these works reinterpreted the Russians textiles of 1920-1930, also known as "Agitational Textiles".

The year 2011 has been declared "Year of Culture: and The Year of Italian Language in Russia and of Russian Language in Italy". The "Ministero Italiano dei Beni Culturali" (Italian Minister of Cultural Heritage) and the "Minister of Culture of the Russian Federation" have reached an agreement to promote initiatives that facilitate cultural exchange between the two countries.

The young designers of the Digital Textile Design course have been invited to reconsider in a contemporary key some of the most important fabrics of the "Agitational textiles", derived from the different textile Russian Collections. So, from this interpretation emerged a small textile collection, that represents not only a simple pattern repeated texture or quotation, but proposes also a real, modern reinterpretation aiming to a rich commercial application, related to the market of textile, fashion and interior design.

The key starting point was the collective construction of a color palette that summed up both the chromatic imaginary Russian identity colors and the real colors, used in the historical period under consideration. Their projects, which were created with digital applications, are be printed by inkjet on fabrics by "Clerici Tessuto" Company.

The result of this work has led to the exhibition: "TEXTILE RE-DESIGN", proposed by Renata Pompas, the Director of annual "Digital Textile Design" Course by AFOL Milano-Moda, in collaboration with the Associazione Italia Russia.

## **An evaluation on the emotion and sensibility on effects of led colors applied to daily clothes**

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### **Abstract**

As IT-based digital lifestyles become a common and ubiquitous trend in keeping with social changes, designs that use high technology to express functionality and creativity are emerging in many sectors. Smart photonic clothing, a type of the smart clothing, is based on light-emitting technology in which LEDs and optical fiber are combined in clothing. Controlling the colors of clothing provides an image of the sensibility of the wearers of such clothes. In smart clothing, LEDs not only enable the realization of various colors but also generate unexpected effects through the changes in the colors, light suffusion rates and degrees of brightness. This occurs because the LED lights penetrate into diverse materials due to its strong brightness and forward progression characteristics. These characteristics of LED are believed to be appropriate for demonstrating potential as a high-value-added fashion product that expresses creativity and originality in the ubiquitous age and as a sensibility-oriented fashion trend. However previous LED clothes are mostly for performance, studies are rarely to be done for daily clothes.

This study seeks to examine the differences of the emotion and sensibility according to the effects of colors of light source and the number of layers. Emotion and sensibility evaluations of various expression methods using LED lights will be utilized as the basic source in LED-applied photonic clothing for everyday life. It can also be used in many different design fields adopting LED as a design component.

## Studying art paintings through a multispectral imaging system composed of light-emitting diodes covering the spectral range from 370 to 1600 nm

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### Abstract

In this work we present the use of a multispectral imaging system covering a wide spectral range for the study of the wall paintings attributed to the painter Ferrer Bassa decorating Saint Michael's cell at the Royal Monastery of Pedralbes (Barcelona), which are an exceptional masterpiece of the Catalan Gothic painting scene. The system used in this study was based in two monochrome digital cameras: firstly a CCD camera with spectral response from 350 to 950nm and spatial resolution of 1392×1040 pixels; and secondly an InGaAs camera with spectral sensitivity over the wavelengths comprised between 900 and 1650nm and spatial resolution of 320×256 pixels. A multiplexed light source composed of 23 light-emitting diodes (LED) with different peak wavelengths and spectral bandwidths was developed to uniformly and diffusely illuminate the analyzed scene. The capturing and illumination systems as well as the processing of the information were computationally controlled using specific implemented routines. From the 23 different images of the scene sequentially acquired by means of the multispectral imaging system, the spectral information over the mentioned range as well as the colorimetric values were extracted pixel by pixel. Calculations of spectral information were achieved by using two different mathematical algorithms: a direct interpolation from the digital responses of the imaging sensors, and through a process of preliminary training of the system and spectral estimation by means of the pseudo-inverse method. In the case of the interpolation results, accuracy was sacrificed for sake of simplicity due to the fact that no training process was required. On the other hand, several color patches containing the basic pigments originally employed in the wall paintings were produced to be used as a preliminary training basis of the system. They were deposited on a lime and plaster substrate, emulating the fresco technique used by the author. These patches included pigments such as indigo, venetian red, ivory black, red ochre, white lead, burnt brown among others. All them were characterized by means of a conventional spectroradiometer as well as using the multispectral imaging system, with the final goal to obtain the proper transform from digital levels to colorimetric and spectral information for the posteriorly running measurements at the Royal Monastery of Pedralbes. Results of simulations and real measurements are presented providing access to spectral and color information of the paintings pixel by pixel. The accuracy of the system in spectral and colorimetric terms is also discussed. The results of this study as well as the methodology proposed can be a powerful tool for art conservators and restorers, since a lot of information related to the original colors and pigments is provided. Moreover, complementary information such as author's underlying drawings are also provided from the multispectral infrared images, which otherwise would remain hidden.



## Color characteristics of the American casual fashion design with inherent symbolic features of black music and paintings

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### Abstract

Costumes express national characteristics and culture of each era and these features have been expressed in various forms of art. After abolition of slavery in America, the black people migrated to the cities and they formed their own cultures presenting them in their paintings, music, and fashion. This study elaborated on black cultural specificities through symbolic interpretation of music and drawings and analyzed color characteristics in black casual fashion design in America.

This research included a literature review clarifying the symbolic interpretation of black painting as a visual expression of language and black music as a linguistic expression systemized through the time. In order to analyze the characteristics of the American casual fashion, websites presenting the brands of black casual wear in America were explored. 1,719 images of men's and women's wear were collected and saved as JPEGs over a period between June 2010 and August 2011. The colors were divided into those used in backgrounds and others used in graphics. Each color of the design was converted to Munsell's H V/C values based on the Munsell Conversion Software 2011 Version. Also, the representative colors and tones were extracted from the analysis of those presented in the background and graphic colors.

In conclusion, the difference in graphic colors of men's and women's wear was insignificant. Overall, the graphics showed a strong contrast of colors and tones. The colors presenting playfulness were prominent in women's wear while those related to aggressiveness were found with men's wear. The common feature was the clear and strong colors expressing extemporaneousness and abstractedness. As for the characteristics of color arrangement in terms of graphic forms, colors with a large difference in brightness and tones were applied to letter patterns to express extemporaneousness and abstractedness. Aggressiveness prominent in men's wear was related to dark colors and with the use of strong contrast between brightness and chrominance. Playfulness found with women's wear was related to complementary color arrangement with high chrominance as well as application of similar colors in addition to being bright and colorful.

## A study of automatic color scheme method for personal website design

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### Abstract

Creating personal website has become a new stage for publishing creative work. However, it is often difficult to a person with no design experience to configure the colors in coordination. In this study, we proposed a systematic method to automatically suggest some color combinations based on the basic concepts of chromatics with the color inference rules during the website design. The method proposed will not only reduce the design complexity of color scheme for nearly naïve designers dramatically, but performs as a useful tool of saving time for experienced ones.

The method we proposed is divided into three phases, including *basic color selecting*, *color fine tuning*, and *webpage assigning*. That is, a harmonic color was selected from a natural photo specified based on the majority of color histogram in the first phase. Secondly, we developed a new color scheming method, which is integrated by the analogous, triadic, split-complementary and double-complementary ones, to fine tune basic color and to determine others required for web design. In the third phase, these colors determined were assigned to the logic blocks, including text content, background, banner, etc., in the predefined webpage layout.

Some experiments will be carried out to evaluate the performance of our system. People with no experience in webpage design will give their color scheme at the suggestion of our system and to verify its improvement for design. It is expected that this automatic system proposed can help both naïve designers and experienced ones to greatly shorten the learning time and reduce their work load to obtain a webpage with acceptable quality.

## Application of camouflage patterns to background for design works

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### Abstract

Although military camouflage patterns have excellent designs and color harmonies that symbolize natural scenes, they have negative images because they are often used on the battlefield.

We utilize the patterns for the background of non-military design works. It makes simple simulations and does not specify the displaying place. The colored and patterned background helps especially the practical choice of color. The merits of the utilization are: 1; many patterns already exist, 2; they simulate country or area and season, 3; they simulate the natural scene without specific form, and so on.

As an example of the practice, the lanterns for an art festival ('Soul of Asuka 2011' held at Kogenji temple in Japan) are designed on the background (Fig. 1). The design source of the lantern is a traditional Korean lantern called Cheongsachorong, typically made by joining red and blue silk shades and hanging a candle inside the body. The color was modified by using color of Japanese national flag to symbolize the friendship between our countries. The camouflage pattern helped to confirm the usage of white color was quite effective in the natural scene. After the design work, the lanterns were made and were exhibited for the festival. The usefulness of the camouflage background for design work was demonstrated.

It can also be utilized for presentation of existing art works simulating the surroundings that displayed. We designed a new camouflage pattern for the work of ceramic art actuality presented at outdoor natural scene. The pattern was printed on the paper base and succeeded to reproduce of the surroundings at indoor.

## Difference of stereoscopic and monocular vision for gonio-apparent surfaces

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### Abstract

Stereoscopic vision and monocular vision are referred to as vision using two eyes and one eye respectively. It is suggested that stereoscopic vision has advantages over monocular vision. For example, it gives a wider viewing field and allows better ability on depth perception. This study investigates which appearance properties of gonio-apparent surfaces are influenced by stereoscopic and monocular vision using a psychophysical approach.

Six types of materials exhibiting gonio-apparent properties were used as the samples in the study. They are: coarseness (three properties: intensity, density and size), glint(three properties: intensity, density and size), gloss, pearlescence, texture, pilling and haze. Ten observers with normal (or corrected-to-normal) visual acuity and colour vision participated in the visual assessments. The observers were assigned a category on a nine-point scale for the each test sample through comparison with a reference sample of various materials. In total, observers judged 220 samples twice using stereoscopic and monocular vision. In total, 8800 observations(220 samples × 2 viewing modes × 2 repeats × 10 observers) were obtained in the experiment. The experiment was conducted under controlled viewing conditions in terms of light source and the angle between light source and observer. Coarseness and glint were judged under a spot light lamp; gloss, pearlescence and haze under diffuse light; and texture and pilling under directional light. To control the angle, coarseness, glint, gloss and pearlescence were placed on a tilting table at a specific angle which exhibits specular reflection. Texture and pilling used a pilling-assessment viewer having directional low angle of incidence light(less than 15°).

The results of the experiment revealed that observers found it relatively more difficult to judge certain properties regardless of mode of viewing. There were glint-intensity, glint-density and pearlescence where the variation for all was significant. Texture and coarseness intensity were the best properties for differentiating between stereoscopic and monocular viewing since they present an obvious difference between the two viewing modes and are relatively easy to assess.

## Color design of luminescent interface display of climate control device

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### **Abstract**

In this study, it is purposed to demonstrate how designers practice the color of luminescent surface and how both confirmatory and exploratory approaches were converged to result a design solution. In a confirmatory part, two empirical studies were conducted in order to investigate whether a condition of indoor climate can be perceived through color. It is focused on the color of luminescent surface facilitated with RGB LED, since this enables a dynamic color expression to the changing climate condition. In the lab experiment (n= 41), subjects were asked to predict air temperature and blow level when they were viewing the luminescent color presented in an interface display of a climate control device. In the field experiment (n= 36), subjects were instructed to match a luminescent color to the given in-car climate condition. Throughout the two complementary experiments, it is consistently revealed that the hue category of luminescent color is related to the temperature while chromaticity level of luminescent color is positively correlated with the blow level. The luminosity level of a luminescent color turned out to be the weakest attribute that nevertheless still influences on the perceived quality of climate. Moreover, the internal consistency was analyzed, and the reliability test yielded a satisfactory level among the answers of the subjects. In parallel to the confirmatory part, as an exploratory approach, a creativity workshop was run with a dozen of designers in order to generate scenarios of presentation of luminescent color of climate control device, and the quality of scenarios was evaluated in terms of interesting, informative, and inspiring aspects respectively. Consequentially, a new scenario of color design labeled as "Eco & Healthy Driving" was proposed that offers both energy saving and health care aspects by changing the hue category of luminescent color, the background of the interface display when the air temperature is either above 26 °C or below 20 °C. The message of hue change is intuitively associated with "undesirable" condition, such as too hot/cold or not necessarily warm/cool. The scenario was implemented by utilizing the database about the color-climate relationship resulted in the empirical studies.

## Hue discrimination under different lighting including LED

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### **Abstract**

Lighting has developed in various types by aid of material and chemistry over these few years. Especially LED (Light-Emitting-Diode) has been replacing not only the special spot lights but also general home lighting. Although the CCT (correlated color temperature) is similarly matched to the contemporary lighting sources such as fluorescent lighting the spectrum differs and that can effect hue discrimination.

For experimental preparation three types of lightings were used; standard D65 fluorescent tube, general household fluorescent tube, and RGB LED lighting. The LED lighting consists of Red, Green, and Blue LEDs that can operate independently and the RGB levels are controlled to match CCT of 6500K. The 'Hue 100 Test' was used as the tool and participants were highly trained 20 females in their 20-30s'. They were asked to complete the task within four minutes under three lightings having 550lx. The average of the error data is plotted against each hue. The error data shows the discrimination level of each hue. D65 has a relevantly broad spectrum while LED and fluorescent has narrow bands at R, G, and B wavelengths. However, in spite of the thought that broadband would be more precise for color discrimination, all three lighting shows similar error for the hue test. All three lightings show high error for Purple-Red. There are slightly higher errors under fluorescent lighting in Green-Yellow. All three lightings show similar error for all hues and prove that color discrimination is not affected by the lighting. This proves that LED consisted with R, G, B LEDs could be used as general lighting that has equal CRI (color rendering index) to general lighting and standard D65 lighting.



## Colour and light: concepts and confusions

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### Abstract

Colour and light are things that all seeing persons perceive, and have often reason to comment, refer to and discuss. Such discussions often end up in misunderstandings due to the fact that both *light* and *colour* have several – and often conflicting – meanings. This causes problems for professionals in either colour or light or both, for example when quantifying light, discussing light qualities or specifying an exact colour and its characteristics.

This paper summarises a project that aimed at sorting out the confusions and at contributing to a better understanding across different disciplines and professions dealing with colour and light. The analysis of concepts was based on the methods of identifying, quantifying and describing colour and light in terms of radiation energy, wavelength, etc., on the one hand and human experience, semantic description, etc., on the other.

There are two basic approaches to formulating terms that define colour and light. The first is based on our visual experience of the world. The second is based on physics as a scientific way to explore nature, and is only a few centuries old. There are also several attempts to formulate concepts and measuring systems that combine experience and physics, such as photometry and colorimetry.

One type of confusion arises from mixing concepts belonging to different academic or professional traditions, as in the photometrically defined measure *luminance* and the perceptually defined attribute *brightness*. Another type of confusion is exemplified by *lightness* and *brightness*. Both terms have specific definitions in perceptual science, but at the same time they have their different usages in everyday language.

A third type arises when general experiences or categories have to be further defined for scientific purposes. These can be similar, but not exactly the same, in different conceptual systems. For example, in everyday language we can talk about *vividness* of a colour and be reasonably confident that we can make ourselves understood; but there are many terms in scientific usage, such as *chroma*, *chromaticity* and *chromaticness*, that have similar or slightly different meanings that can still differ from the everyday concept of vividness.

Especially problematic are words that are given alternative conceptual definitions, while having a more or less established everyday usage. Take for example *saturation*: even if each of the definitions is clear, it is very confusing that one term can have many definitions.

There are also generic words and terms that have very specific meanings within a given scientific discourse. These can be misunderstood or confused with their more generic meanings. Examples are *inherent colour* and *identity colour*. Within the framework of their discourse these terms are well defined (and thus useful), but outside that framework they can cause confusion.

## Design of digital pseudo-isochromatic plate for checking Deuteranopic vision

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### Abstract

A computer software named Digital Colour Vision Test Plate (DCVTP) was developed. It relies on a calibrated LCD monitor. In our previous studies, the experimental procedure for examining deuteranope using just-noticeable chromatic difference (JNCD) was established. The results revealed that the DCVTP can accurately detect deuteranopic vision. In this study, JNCD for a deuteranope under different luminance values was investigated. It can be thought that a normal colour vision (NVC) observer can discriminate the specified coloured text on a coloured background, if colour difference between them are large than a corresponding JNCD. However, a deuteranope could not distinguish the colour pairs (text colour and background colour) along the corresponding deutan line of confusion.

**Fig.1** shows the developed Graphic User Interface (GUI) for determining JNCD. **Fig. 2** shows five initial test colours selected from the colour centres of 25 MacAdam ellipses which were determined of inside three Y tristimulus value in CIE u'v' chromaticity diagram in the experiment. Using an sRGB display, each initial test colour was set at three Y tristimulus value at 5, 20 and 50, while the Y value of peak white of the monitor is set at 100. There were 10 paths for each initial colour in CIE u'v' diagram, for which eight of them were 0, 45, 90, 135, 180, 225, 270 and 315 degrees and the other two directions were the line linking the initial colour towards the copunctal point for a deuteranope in CIE u'v' chromaticity diagram. For each fixed direction, the subjects were asked to adjust text colour via a control bar until text colour and background colour showed a just-noticeable difference. The developed DCVTP is described by Equation 1,

$$DCVTP(i,j)=Text(i)+Ground(j); \quad i=1\sim 3, j=1\sim 3 \quad (1)$$

where i and j represent the numbers of colour used as text and background respectively. **Fig. 3** shows the chromatic differences of three test plates in terms of  $\Delta u'v'$  of 0.00, 0.02 and 0.14, respectively and three types of pseudoisochromatic plates in this study, including two kinds of DCVTPs (i.e., DCVTP(1,1) and DCVTP(3,3)) and one typical plate of concentric circle. **Fig. 4** shows three types of JNCD ellipses (i.e., concentric circle, DCVTP(1,1) and DCVTP(3,3)) at different Y values adjusted by one NCV subject and one deuteranopic subject. The results showed that a NCV subject yields an ellipse close to a circle. However, the long axes of JNCD ellipses for the deuteranopic subject lie approximately towards the direction of co-punctal point. Five NCV subjects and five deuteranopic subjects are currently conducting the experiment. Their results will be reported in the full paper.

## Study on color discrimination of the elderly sight considering yellowing and opacity of crystalline lens

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### Abstract

With the increase in age, the function of a sensory organ is aging. Due to aging of vision that takes over 80% of information acquisition, the elderly people may perceive colors in everyday environment differently and unpleasantly or may not perceive important information to cause inconvenience. Moreover, they are in a degraded state physically, there might happen a hazard to safety in a moment. From this point of view, in time of planning color environment, a substantial consideration about visual characteristics of the elderly people should be applied. Also, the elderly people tend to be more active inside than outside, and they may need to move around during nighttime. Artificial light environment as well daylight should be considered significantly.

Thus in this study, color discrimination with different light sources based on same illumination range and color temperature was quantitatively compared and analyzed in the elderly sight considering yellowing and opacity of crystalline lens. Light sources used in experiments are D65 standard light source and LED. Illumination range on the experiment surface with the light sources are 1030~1034 lx. 16 experiment subjects are professionals majored lighting and color and are highly trained for measuring colors with naked eyes. They wore elderly filter glasses for the experiment. There are 2 types of elderly filter glasses: One is the filter glasses reproducing yellowed eye sight by yellowing of crystalline lens, and the other is filter glasses reproducing low contrast as like seen blurredly in recognizing the shape and color of material by cloudy crystalline lens. They wore both types of glasses at once for the experiment. The evaluation sheet used in the experiment is composed of Y and Y50R among NCS color specification system in the scope of less than 35% of blackness, and less than 20% of chromaticness. It is used much as the dominant or assort colors for building exteriors and interiors. Subjects adapted to each experimental light source for 1 minute with the senior filter glasses on. Then, using the evaluation sheet produced beforehand, the experiment was repeated 2~3 times. As the result, perceivable color range by light source was drawn by frequency analysis and average analysis.

## A study on the preference for the dwelling landscape in agricultural and fishing village according to location type

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### Abstract

This study proposed color arrangement for housing scenery of farm villages considering Korean sentiment and preferred housing scenery of farm village by extracting vocabulary expressing images of Korean farm housing scenery. The study is proceeded largely in three phases and the process for each phase is described as follows.

First, After selecting evaluation targets from Korean farm housing scenery, a free association test was executed to extract image vocabulary. Extracted vocabulary was sorted by frequency. Positive words with frequency of 10 or higher were finally selected. Selected words is 『Comfortable』, 『Harmonious』, 『Semirural』, 『Pleasant』, 『Neat』, 『Pleasant』, 『Natural』, 『Colorful』, 『Rich』.

Second, From Korean farm scenery described in ‘Framing an Application Model for Environment color to Make Rural Landscape Image’ report researched and issued by Korea of Ministry for Food, Agriculture, Forestry and Fisheries and Chungnam National University in 2009, color palette for housing was collected. To evaluate and test preferred scenery images, 4 evaluation models were made each for ‘Same Color’, ‘Similar Color’ and ‘Opponent Color’, color arrangement method based on colors, and total 12 simulations were done. In each evaluation model, Dominant color1 was designated as roof, Dominant color2 was designated as wall1 and Assort color was designated as wall2.

Third, With finally selected evaluation vocabulary and complete evaluation models, an experiment was executed in SD method. Then, in order to analyze evaluation structure of models for evaluation of each color arrangement method, a factorial analysis was executed. By placing each evaluation model of each color arrangement method on factor side, evaluation characteristics of evaluation models were identified for suggestion of preferred color arrangement.

This study is meaningful because it suggested color arrangements for Korean sentiment and pursued housing scenery of farm villages by selecting only Korean farm housing scenery. However, this study has limits because it limited test subjects to only a small portion and color arrangement method to colors. Further studies regarding such limits and continuous studies with various factors are demanded in later studies.

## Color constancy on red-green color deficient observers under illuminant change on confusion lines

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### Abstract

Strength of color constancy performance was measured on 2 color normal observers and 3 color deficient observers (1 protanomalous trichromats and 2 deuteranopes), especially in order to investigate about influence of observer's detection of illuminant change. On a CRT monitor, a standard pattern was presented as if it was under illuminant D65 and a test pattern was presented under test illuminants those were obtained by increment or decrement of M-cone stimulation in 5% or 10% from D65 along individual confusion lines of color deficient observers. Observers performed paper match between two central patches (1-deg-square) in these patterns presented side-by-side.

The stimuli were presented on the screen of a 1024\*768 resolution, 120 Hz frame rate, 19-in. CRT color monitor (Sony, Trinitron G420), controlled by a computer with ViSaGe (Cambridge Research Systems) providing 14-bit resolution per each phosphor. A 90\*60 cm black paper board was put upright in front of the screen to separate two pattern presentations on the screen, making the haploscopic view in which the left half of screen viewed by the left eye and the right half viewed from the right eye. Both standard and test patches were surrounded by the background (5-deg-square) in which about 230 superimposed chromatic ellipses were drawn. The backgrounds of two patterns were identical in spatial arrangements of ellipses, but illuminated by different light sources. We used 60 kinds of test conditions from 12 colors of standard patches under 5 test illuminants. Each condition had 6 trial in 6 different sessions.

Observers adjusted the chromaticity and luminance of the test patch with a six-button response box (CB6 response box). Observers were asked to make the test patch appearance as if it were cut from the same piece of paper presented in the standard patch. Individual confusion lines and abilities of color discrimination were defined by the axes and size of discrimination ellipsoids in Cambridge Color Test.

As the results, two deuteranopes indicated almost no color constancy. The color constancy performance of the protanomalous observer is similar with that of the color-normal observer with lower color discrimination ability. The color constancy performance of the color-normal observer with lower color discrimination ability is not so good as that of the color-normal observer with higher color discrimination ability. These results suggest that the color constancy performance can be influenced by the detection of chromatic change of illuminants.

## On the environmental role of blue

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*The present Poster aims at describing some psychophysical experiments performed by the author, preceded by a study of the history of the escalation of the hierarchies of the response to blue, that is, from local to global, from simple to complex. The used tools of visual functionality range from brightness match, visual scaling, speed of reading, visual balance, by including the Purkinje effect. The test objects used by us consist of colored samples or cardboards, or the observers used colored spectacles, looking at achromatic test objects,*

### Abstract

The independent variables are the illuminance, as related to adaptation and to brightness, the time of day, related to circadiancy, and the retinal eccentricity representing the visual field, where the environment is imaged. It allows relating our data to the modern research, following the discovery of a novel photosensitive receptor in particular, the ganglion cells containing melanopsin, the ipRGCs, sharing the action spectrum with the night suppression of melatonin, peaking in the blue (Brainard, 2001). Now, thanks to the "giant" ganglion cells the traditional visual (imaging) channel and the non-visual (non-imaging) channel interactively conjoin (Dacey, 2005). It involves the luminance coding and related (unconscious) perception of brightness, which thus represents a neural input, controlled by an exogenous fact (the light), in turn converted to an endogenous glandular output, thus calling into play the biological rhythms

The debates related the above modeling, include the possibility that either the melatonin contribution coexists or is excluded, replaced by the S-cones. Now, the S-cones, originally named "blue cones" are distributed across the extrafoveal retina, where the environment is imaged.

The plot of the responses gathered in our experiments versus the time-of-day look complicated, because of the overlap of various component, differing in amplitude, phase, timing, and location of the peak. By putting together the data recorded at various times of day, we find that the overall variability is smallest for blue. Note that the non-visual effects refer to the performance, since they operating at higher level, in interactive conjunctions (Rea et al. 2011) In particular, the history of the hierarchical escalation of the blue perception is a topic of great interest.

In conclusion, as environmental illuminance increases color appearances changes. If it is not requested by the task or by the behavior, the observer can discount the illuminance, with perceptual constancy, prototypicality, synesthesias.symbolism. Otherwise he can use the fine discrimination, having at his disposal two modes, choosing the broadband tuning or its fine details.. The blue is always the winner: e.g., with the rod bias in the case of Purkinje, with the prevailing blue-yellow opponency in the case of Bezold- Bruecke effect



## Color preference style for twelve tones in the practical color co-ordinate system (PCCS)

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### Abstract

Hanari & Takahashi (2009) called the individual profile of the preference for many colors ‘color preference style.’ This study examined the color preference style for the twelve tones described in the Practical Color Co-ordinate System (PCCS) developed by the Japan Color Research Institute. The PCCS describes all colors in two dimensions, hues and tones. The PCCS tone is the concept that combines the value and the chroma, and is classified in twelve categories; pale, light grayish, grayish, dark grayish, light, soft, dull, dark, bright, strong, deep, and vivid. For example, the vivid tone has a middle value and the highest chroma.

The card on which color chips arranged in twelve rows by twelve columns were pasted was distributed to the 353 participants. Twelve columns corresponded to twelve PCCS hues; red, reddish orange, yellowish orange, yellow, yellow green, green, blue green, greenish blue, blue, violet, purple, and red purple. Twelve rows corresponded to twelve PCCS tones. Consequently, twelve color chips in each row had the same tone of different hues. Another sheet of questionnaire was given to the participants to ask the preference for the twelve PCCS tones. In the questionnaire, twelve horizontal lines were drawn to serve as visual analog scales (VAS). Participants were asked to judge the degree of preference for the whole twelve color chips in each row. They answered that by marking a slash (/) on each line. The left edge of the line indicated ‘dislike the most,’ and the right edge indicated ‘like the most.’

We calculated six indices of the color preference style in each participant; the average, the standard deviation, the highest and the lowest of 12 VAS scores, the degree of extremity of the highest (DEH) and of the lowest (DEL). The DEH (DEL) is the mean of differences between the highest (lowest) score and other 11 scores. These indices indicate how extremely the most preferred (or the least preferred) tone stands out from other tones. The color preference style for the PCCS tones showed different properties from that for the basic hues. The average, the highest, and the lowest scores were smaller for the PCCS tones than for the basic hues, suggesting the overall level is lower for the PCCS tones than for the basic hues. The lowest score was smaller, and the highest score was larger in females than in males. The DEH and the DEL were also larger in females than in males. These results showed the consistent tendency that female participants had more choosy preference style than male. That sex difference was not found in the case of the color preference style for the basic hues.

## Hue adjustments for stereoscopic 3D perception

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### Abstract

This paper discusses the effect of hue on stereoscopic 3D (S3D) perception from a psychophysical viewpoint. It considers the way in which S3D perception is influenced by different decisions of colour hue, and identifies the thresholds of S3D perception in several hue adjustments, which can provide guidance during colouring decisions for S3D imaging.

Colour is a remarkable monocular depth cue that advantages binocular depth performance; it is also highly related with depth perception in graphic design. Hue is a crucial consideration in S3D imaging design where depth is most concerned. Previous work in colour stereopsis has shown that long-wavelength stimuli, such as red or yellow, compete with short-wavelength stimuli such as blue or green, when viewed binocularly, reds and yellows appear closer than blues or greens. In other words, warmer hues associated with longer wavelength helps objects stand out; cooler hue helps objects recede.

From design aspect, either a warmer hue for the foreground objects or a cooler hue for background objects can contribute to colour stereopsis. However, are there two approaches intrinsically the same? Is one of them more effective to reach preferred stereoscopic performance? This paper examines the thresholds of stereoscopic depth perception in both approaches.

In particular, different levels of hue are tested on foreground and background objects in computer graphic scenes. Psychophysical trials are utilized to examine the thresholds of observers' depth perception. A polarised projection system is built for stereoscopic viewing and the image stimuli are rendered from stereoscopic virtual cameras by renowned 3D film making programme during experiments. The trials provide the data that indicates the preferred arrangements of colour hue for the enhancement of S3D perception.

## Blackness of Japanese lacquer and its relation to surface property

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### Abstract

In Japanese, there is a word to express a kind of black, “Shikkoku” which means “lacquer-black” indicating deep black. It is interesting that sometimes it indicates a blackness of dark space with no lights, and at other times it indicates a glossy black, implying that the expression tightly relates to the appearance of lacquer materials which varies from simple matt to gorgeous luster. Such difference of appearance of lacquer is based on the difference of physical properties of surface resulted from the difference in the polishing and finishing process. So we become interested in investigating that what kind of physical property causes the difference of material appearance of black lacquer. Previously, we investigated the effect of observer’s property on KANSEI impression of blackness in artistic images using digital images of lacquer objects and western masterpieces [1]. We found that observer’s interest, knowledge, and experience on arts affect on the perception of blackness, especially in the images with artistic contents. Therefore, the purpose of this study is to investigate the relation between perceived blackness and physical properties of the surface of black lacquer, and further to explore whether any dependency exists between observer groups of the Engineering and Art course students.

We prepared small wooden plates painted with 2 different lacquers produced in Japan and Myanmar. For each of them, plates were stopped at 3 different steps in the process of making lacquer products, called “Nuri-tate”, “Do-zuri” and “Roiro-migaki”, corresponding to the early, middle, and the last steps of the painting, polishing, and finishing process.

In the psychophysical measurements, we prepared a reference stimulus that has a concentric visual field, dark center surrounded by white area, and the blackness of the center can be varied by changing its luminance. We called it “Blackness matching box”. Perceived blackness of the real lacquer and fake plates was evaluated by comparing its blackness with that in the blackness matching box. “Roiro-migaki”, the plates proceeded to the last step, was the blackest, and “Do-zuri”, the plates stopped at the middle step, was the least black. Individual differences of the results of art course students are significantly larger than those of engineering students.

In the measurement of physical properties, luminance measured from the observing position, surface roughness, reflectance, and BRDF (Bidirectional Reflectance Distribution Function) are being measured. Correlations between these properties and the perceived blackness will be shown in the presentation at the conference.

## Comparison of color preference in different color appearance mode between Thai and Japanese people

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### Abstract

Previous research has shown the comparison of color preference between several nations. However, most of those works studied color preference with real and simulated reflected surface which appeared in object color mode. None of them include mode of color appearance as a factor. In our daily life, however, colors are perceived not only as an object color mode, but also as other modes, such as unnatural object color and light source color modes. In this study, we then investigate color preference in different color appearance mode of Thai and Japanese people. The stimuli are selected from eight colors (red, yellow, green, blue, orange, purple, greenish yellow and bluish green). Eight Munsell colors (5R, 5YR, 5Y, 5GY, 5G, 10BG, 10B, and 5P) are selected to represent the eight colors. Each hue consists of three values/chromas (5/2, 5/5 and 5/8) which is a total of twenty four color chips. The color chips are presented in different color appearance modes by changing the subject's room illuminance and the color chip room illuminance. The experimental condition is composed of a combination of two subject room illuminance levels (50 and 500 lux) and three test chart room illuminance levels (300, 500 and 700 lux). There are two tasks for each subject. First, the subject is asked to rate his/her color preference on each color according to the categories of like, dislike, or neutral by using a color preference scale. The scale is divided in to seven steps from -3 to +3, where -3 means "most dislike" and +3 means "most preferable". Second, the subject is asked to judge the color appearance mode of the color chips whether it appeared as an object color mode, unnatural object color mode and light source color mode. The result showed that in ever mode of appearance, color preference of Thai and Japanese people shows similar tendency. Firstly, vivid colors are preferable to pale colors. Secondly, colors appeared as unnatural object color mode and light source color mode are preferable to those appeared as object color mode. Thirdly, yellow color is the least preferable hue for both Thai and Japanese. We also found the different result of color preference between the two groups. Thai people prefer cool colors like green, blue and cyan to warm color (red, orange), whereas Japanese people prefer warm colors to cool colors.

## Categorical color perception in color defective observers - Effect of viewing condition and degree of defect

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### Abstract

Although people with color defective are difficult to discriminate certain color combinations, they use various color names as many as color normals. This is because they determine color name based on clues from surround. In this paper, in order to clarify the mechanism of the color recognition of color defective people, it was investigated how their categorical color perception would change if viewing conditions and clues for color judgment changed. We also examined how categorical color perception was influenced by the degree of color deficit.

In the experiment, observers answered color names of 149 Munsell color chips after 5 minutes-adaptation to a white illumination of a viewing booth. We compared two responding methods: a categorical color naming method using color names restricted to eleven categories and a free sorting task without restriction of the number of color names. All color chips were given to observers so that they were able to compare those chips side by side. We additionally conducted the condition judging one color chip at a time to test the influence of viewing condition with and without various colors at the same time. To test the influence of clues in surround further, we also conducted conditions with a Macbeth Color Checker as a reference for color judgment.

Three observers with normal color vision, five deuteranomals (three severe deuteranomals and two mild deuteranomals) participated. SPP, anomaloscope, Ishihara's tests for color deficiency and panel D-15 were used for color vision test. As results, the color categories of mild deuteranomals were almost the same as those of color normals, whereas those of severe deuteranomals were different in most conditions. Moreover, as the clues of color in surround increased, the response of severe deuteranomals was stabilized, and it became almost the same as that of color normals in the condition with rich clues. It was suggested that the difference in categorical color perception of observers with color defective from normal color vision were correlated with the degrees of defect. Furthermore, the clue of colors in surround plays an important role in categorical color perception.

## The relativity between color imagery and harmony of color-apparel images in yellow series of color combinations

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### **Abstract**

The relativity between color imagery and harmony of 30 samples of fashion apparel images having various color combinations accumulated in this study was investigated. Three color attributes and color difference between the dominant and secondary colors for each sample were also used to estimate the tendencies of color imagery and color harmony respectively. The experimental results indicate that the darker the dominant and secondary colors in color combinations of fashion apparel images, the more negative tendency the color imagery and harmony is. Color imagery has high agreement with color harmony. That is, the more positive the color imagery of color-apparel images, the higher the harmony is.



## Preference for product color combinations - Differences in constructing color numbers

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### **Abstract**

A study on product color preference was presented at AIC 2008. In that study, subjects reported their preferences toward product images in which various colors were interchangeably used in a color area covering the entire area of the product. The data obtained show that people tend to prefer light blue, red or black personal products (purses, glasses, etc.) over public products (air conditioners, sofas, etc.) of the same colors. The opposite tendencies were obtained when white or beige was used. In the present study, two experiments in which products had multiple color areas were conducted.

The products in the first experiment had two color areas. A total of 400 product images, all combinations of twenty-five color patterns and sixteen products, were displayed on a screen by using a liquid crystal projector. In the second experiment, in which products had three color areas, the combined images of fourteen products (including an abstract image) and forty color combinations were used. The latter are representatives of each of various sample clusters that were obtained by a cluster analysis of the color difference data of 637 product images. These images were collected from websites.

Thirty female students in the first experiment and forty in the second one rated their preferences toward each product by using 7-point scales.

The two main results are as follows:

(1) The principal component analysis of the mean values of the ratings in the first experiment shows that the contribution of the first principal component is 74%. The value obtained in the second experiment is also high, 72%. These results indicate the preference differences among the products are small, and suggest that products with multiple color areas are evaluated differently from those with a single color area.

(2) The order of preference is strongly influenced by the actual colors used as components in a particular combination, rather than the relationships among the component colors, such as in a combination of similar or contrasting colors.

Overall, subjects in the first experiment tended to prefer patterns in which the color areas were whitish, and those in the second experiment preferred the combination of high-brightness and low-saturated colors. However, low values were obtained for combinations of highly saturated colors.

## Effect of ambient illumination on color preference

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### **Abstract**

It is well known that color is one of the critical factors influencing customer's satisfactory; an understanding of color preference is thus important in many fields, for instance, product designs, advertisings, marketing, lighting designs and so on. Color preference indicates whatever a color or color combination is preferred by a group of viewers. It was also referred to as an estimate for the pleasantness of a color so that the color preference is a powerful tool to attract a subject's attention and to arouse the desire to consume. Studies on color preference have long focused on the hue effect; what colors were generally preferred and what colors were not. Many researchers have attempted to deal with color preferences and their variations as a function of age, gender, geographical region, culture, and circumstances. Along with the aforesaid variations, color preference also depends on illumination. In our daily life, color is observed under plenty of ambient illuminations. For instance, the color in advertising billboards is viewed under daylight on daytime and under ambient illumination on nighttime. Is there consistency in color preference on different illumination? The major aim of this work, hence, is to investigate the relationship between color preference and ambient illumination.

In this experiment, an effect of ambient illumination on color preference was carried out. Twenty-five colors varying in hues and chromas were presented under various ambient illumination conditions that consist of three set of orange and blue illumination and one set of white illumination ( $D_{65}$ ). Each illumination condition was kept constantly at 80 lx. There were two tasks for each subject. First, the color preference score assigned from -3 to 3 according to observer's like-dislike feeling. The last one, subjects did the elementary color naming by giving percentage for perceived chromaticness, whiteness, and blackness. Expected experimental results will show the relationships between the ambient illumination and color preference. A difference of color preference among variation of ambient illumination is also revealed. Color preference might be inconstant when colors are viewed under extreme illumination condition, but might be unchangeable under moderate illumination condition. This result could be explained by one of human visual system properties named color constancy. Our results might be a basic knowledge to express color and illumination as a practical application tool for lighting designers.

## Sensibility factors of single colors for product design

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### Abstract

This study aims to extract vocabularies representing single color sensibility in an expanded range comparing with previous studies utilizing a systematic approach. We eventually intend to locate sensibility factors underlying single colors that are practically applicable for product design ideation processes.

First, 850 adjectives specifying sensibility were collected from a comprehensive range, and 230 adjectives were selected through questionnaire surveys on validity within design context. After compatibility tests as color vocabulary, the adjectives were further narrowed down to 160 words, and 43 sensibility words were finalized through cluster analysis.

To extract sensibility factors underlying single colors, 30 subjects have evaluated 35 respective colors presented on a computer monitor using monopolar scales of 43 adjectives. The color stimuli needed to be minimum in number yet an effective representation of a color space. 35 colors were systematically selected from PCCS Color System: 6 primary hues and 5 tones for each hue group, and 5 additional achromatic colors. For evaluation, subjects rated the perceived strength of a single color against 43 respective adjective scales on a seven-step rating scale.

The factor analysis on the evaluation data has yielded two sensibility factors which were elegant-lively and natural-unique. These results reflect sensibility keywords frequently adopted in current product design processes implying that the two factors play focal roles in the application of color in design. In addition, correspondences between adjectives and colors within the two-factor space revealed that distribution of sensibility words depended on tone criterion rather than hue criterion. For the first axis of “elegant-lively”, colors of grayish tone and medium grayish were distributed along “elegant”, and colors of vivid, light<sup>+</sup> tone were arrayed along “lively”. For the second axis of “natural-unique”, pale tone, and white were distributed along “natural”, and “unique” drew dark tone and black. These results indicate that a valid correspondence between a single color and a factor image exists, and tone is more influential than hue in creating sensibility for a certain color.

The two factors derived from this study account for color sensibility more specifically than the factors that have been previously proposed. Issues on the interpretation of factors and possible implementation of these results in product design practice are also discussed.

## Psychophysical study on mesopic vision at different adaption levels and viewing conditions

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### **Abstract**

We investigated the change of spectral visual sensitivity in the mesopic vision range wherein both rod- and cone-photoreceptors operate. The rods and cones are different in their properties of temporal and spatial responses. Moreover, they are differently distributed in a retina. Thus, the spectral visual sensitivity in the mesopic vision range changes depending on the adaptation levels and viewing conditions.

For experimental study, we measured spectral visual sensitivities for the various adaptation levels and viewing conditions by using a detection threshold method corresponding to a psychophysical method for measuring spectral visual sensitivity. The adaptation levels were set as three mesopic vision levels of 0.04 cd/m<sup>2</sup>, 0.4 cd/m<sup>2</sup>, and 1.8 cd/m<sup>2</sup>. The viewing conditions were selected as 2° and 10° centrally viewed fields and the (10-20)° peripherally viewed field. In the experiments, we used a uniform integrating sphere source as a visual stimulator. A flickering monochromatic target light with a rate of 10 Hz was superimposed on a white background of adaptation field.

Two normal trichromatic subjects participated in the experiment. The power of the target field was adjusted until a subject perceived no flicker. The radiance of the target field at the psychophysically determined detection threshold was measured with a spectro-radiometer, the inverse of which corresponded to the visual sensitivity at the wavelength of the target. Repeating the measurement procedures with various monochromatic targets yielded a luminous efficiency function.

As a result, we obtained mesopic luminous efficiency functions depending on a background luminance and a viewing angle. The observation is discussed in terms of the interaction between the rods and cones. Also, we observed a separation of rod- and cone-contributions for the measured data at different viewing conditions. We obtained a cone-dominant function for the data of 2° centrally viewed field, a rod-dominant function for the data of (10-20)° peripherally viewed field, and both rod- and cone-mediated function for the data of 10° centrally viewed field.

## Estimating object colors in outdoor scenes with same object region but different illuminants

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### Abstract

It is useful for image analysis to express the colors of objects under a white illuminant, because colors of images taken with a camera vary depending on the scene illuminants. These color changes occur especially in outdoor scenes; however, to date no appropriate method for estimating the colors of objects in images has been proposed.

Our objective is to estimate the colors of objects in outdoor images under an unknown illuminant. In the estimation process, we express the pixel value as the product of the illuminant and the object colors and approximate the illuminant in an outdoor environment to blackbody radiation following by Planck's law. We propose a way to estimate the colors of objects from images that have the same object region under different illuminants in outdoor scenes. Colors from the same object region in images divided by the illuminant color are shown as the colors of objects. By applying possible color temperatures to the blackbody radiation as the illuminants, we derive a set of object color candidates that includes the correct one. Since the candidates in the set are empirically expressed as quadratic curves in an xy chromaticity diagram, the point at which the curves intersect is regarded as the object color.

Experiments are conducted using 100 kinds of object reflectance selected from ISO/TR 16066 and three illuminants: sunlight at noon (6500 K), twilight (3000 K), and blue sky (10,000 K). First, objects' colors are calculated using the reflectance and the illuminant's distribution as simulated colors of the object region in images. The calculated colors are then used to estimate the color of each object. Results show that the estimated object colors are close to the correct ones ( $\Delta E$  is less than 0.01 in a  $u^*v^*$  chromaticity diagram) except in cases where the candidate curves are almost parallel and cannot find points at which to intersect each other. This tends to occur when the reflectance has a relatively higher value at the middle and long wavelengths than at the short wavelength.

To summarize, an algorithm is developed to estimate the colors of objects in outdoor scenes using colors of the same object region but different illuminants. Experiments show that restricting illuminants to blackbody radiation enables accurate estimation results to be obtained in all but a few cases.

## The effect of differences in substrate white point on the acceptability of colour matches

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### Abstract

A common colour reproduction task is to take a colour image on one substrate and reproduce it on a different substrate. An evaluation of the closeness of matching using colorimetry relative to a perfect diffuser may not predict the visual closeness of the match, as it takes no account of the change in adapted white point.

Work on colour matches on chromatic substrates indicates that the degree of adaptation to the substrate colour is fairly stable at about 70%, regardless of the lightness and chroma of the substrate. A common colour management solution is to base the matching entirely on media-relative colorimetry; however, if adaptation to substrate white point is incomplete this may lead to unacceptable colour differences between original and reproduction depending on the degree of difference between substrate white points.

Several use cases are of interest in a colour management context. In the first case, substrates appear different as a result of variation in the degree of fluorescent emission owing to differences in the levels of optical brightening agent in the substrate or the UV content of the viewing illumination. In the second case, an original is re-targeted to a medium with a different white point from the original. In both cases, the media white may be a physical substrate or a computer display.

If the reproduction goal is a corresponding colour reproduction (i.e. matching appearances but not absolute luminance levels), the ultimate objective is to model the appearance changes in a way that will allow prediction of the target colour on different substrates.

Experiments were performed to provide some psychophysical data to contribute to understanding of these issues and the development of appropriate colour management solutions.

In the first series of experiments, observers matched display images with printed ones on optically brightened substrates under different levels of UV content in the illumination source. The observer matches had large colorimetric differences, which were partially accounted for appearance model adjustments between the viewing conditions.

In the second series of experiments, the acceptability of hard copy matches on different substrates was evaluated when both media-relative and partial-adaptation models were applied, and the magnitude of substrate colour difference producing acceptable matches was determined.



## Repeatability and reproducibility of a hyperspectral camera as a means of measuring color

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### Abstract

Hyperspectral cameras, which allow measuring the complete spectrum for each pixel of an image, have appeared on the market in recent years. Their main components are a digital camera, a spectrograph and an objective lens. An additional moving system allows scanning mechanically the complete scene, although sometimes the scan is performed optically. Using such systems, the scene is sampled spectrally but also spatially, creating a 3D cube of data ( $x, y, \lambda$ ). In this work we analyze the repeatability and reproducibility of a hyperspectral system (16-bit camera: AVT Pike F-210B; Spectrograph: ImSpector V10E; Lens: Cinegon 1.8/16) as a means of measuring color. We followed the guidelines specified in the ASTM E2214-08, where the latest multidimensional procedures for characterizing the performance of color-measuring instruments have been established.

To analyze repeatability we performed measurements on a calibrated white plate (BN-R98-SQ10C) and used univariate and multivariate metrics. 50 consecutive readings were taken to account for short-term repeatability, 50 in two consecutive days for medium-term, and 50 along 5 weeks for long-term. To account for reproducibility we used two different sets of samples: 12 glossy ceramic tiles (BCRA CCS-II) and 24 matte patches (CCRC). The multivariate Hotelling and inter-comparison tests were used to compare the readings with those obtained by a conventional tele-spectracolorimeter (PR-655). The reflectance factors from 400 to 700 nm ( $\Delta\lambda=10$  nm), a bidirectional geometry of 0/45, illuminant D65 and CIE 10° observer were used to compute the color data.

The results confirmed the good performance of the hyperspectral system in terms of repeatability. For instance, parameter  $\Delta R_{560,2\sigma}$ , which represents twice the standard deviation of the reflectance at 560 nm was of 0.001 (short), 0.01 (medium) and 0.02 (long). In terms of RMSE, results were 0.14% (short), 0.66% (medium) and 1.87% (long). Using CIEDE2000 color differences the values were 0.03 (short), 0.13 (medium) and 0.40 (long). In the case of reproducibility, the two tests applied reported statistical significant differences between the hyperspectral system and the tele-spectracolorimeter ( $p<0.001$ ). However, it must be mentioned that the statistical tolerance using the methodology proposed by the ASTM E2214-08 is strict as already reported by other authors. The majority of the samples showed RMSE below 10% and CIEDE2000 differences below 2, which is acceptable. The results were better for the CCRC patches than the BCRA tiles. This might be explained by the gloss of the last set of samples and the bidirectional geometry used (0/45), which could contribute to a higher variability among the results. Darker patches as well as those with a high reflectance factor in the green-yellow region, where the observer has its maximum sensitivity, were also associated with worse results.

In conclusion, it could be established that the hyperspectral system provided very good results in terms of repeatability and acceptable data in terms of reproducibility. Therefore, these systems are reliable and could be used in the industry providing advantages in the field of colorimetry, mainly in the characterization of non-uniform materials.

## Novel neural network application for printer characterization

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### Abstract

The ability to be able to develop computational models that can relate a printer's colour space (e.g. CMYK) to a device-independent colour space (e.g. CIE XYZ) is an important requirement for colour management. Various models have been used including look-up tables and tetrahedral interpolation. Neural networks have been used over the last twenty years for this application. However, one of the problems with neural networks is that the number of free parameters (known as weights) can be high; especially for the case where the device-independent space is spectral (so that spectral rather than colorimetric characterization is performed). For the most common type of neural network (a multi-layer perceptron) the number of free parameters that need to be determined for a network with a single hidden layer with  $n$  units that is used to approximate the function between CMYK and a 31-dimensional spectral space would be  $5 \times n + (n+1) \times 31$ ; for  $n=10$ , for example, this is 391. For such a network, the number of training samples required so that the model does not over-fit the data is huge. One reason why neural networks have not been more successful for printer characterization is that the complexity of the network required to solve the problem would require prohibitively large numbers of training samples. In this research, a novel neural network architecture is presented that resolves this issue. In this new neural network scheme the number of weights in the network is effectively reduced from  $5 \times n + (n+1) \times 31$  to  $5 \times n + n+1$  or less. For  $n=10$  this is a reduction from 391 weights to 61. Details of a study will be presented using a HP Color LaserJet 5500n printer. The IT8-7-3CMYK colour chart was printed and the spectral reflectance factors measured using a reflectance spectrophotometer at 10-nm intervals. The colour patches were randomly separated into a training set of 778 samples and a test set of 150 samples. The performance of the neural network on the test set of data will be compared with the performance a distance-weighted interpolation algorithm. The advantages and disadvantages of the neural network approach will be discussed.

## Methods for capturing and analyzing digital images of cultural heritage

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### Abstract

Recent years, many museums and archives are engaged in direct digital image capture of cultural heritage. In Taiwan, National Palace Museum has a great number of ancient paintings and utensils including ceramics, bronzes and jades *et. al.* They are priceless, fragile and photosensitive, therefore the procedure of image capture should be standardized and carried out in very limited time. Painting needs a uniform lighting whereas utensils prefer uneven lighting to enhance the reflective highlights and shadows. The optimal setting is normally on a case-by-case basis. The color and surface property of the cultural heritage have great value for industrial design. However, the uncertainty of lighting setup makes the image-based color analysis more difficult. The present paper aims to recommend a SOP of digital image capture for painting and utensils and to propose methods to analyze the colors for further applications (e.g., industrial design).

In terms of image capture, ICC-based colour characterization [1] is essential to the digital camera. To analyze the color characteristics of a painting, we need to: (1) equalize the light distribution based on non-reflective background of the captured image, (2) correct the tone curve and color based on a given color target (e.g., Color Checker or Kodak Q13), (3) filter and downsize the image to simulate vision blur in typical viewing distance [2], (4) select a region of interest (ROI) to filter the edges and isolate points in the image content, (5) apply a modified K-means clustering algorithm to determine color centers in CIELAB space, (6) regard the color centers as representative color patches and then convert their LAB values to the other color order systems (spaces) such as sRGB, HTML, ISO CMYK, NCS, Munsell, PCCS and Pantone, (7) summarize color statistics of the ROI.

To measure the gloss and diffuse components of a utensil more accurately, two exposures with different lighting geometries are recommended. The two components can be separated by comparing the image differences of the two images. [3] If the surface of the utensil is homogeneous, one image is enough to estimate the glossiness and shadows. [4] The proposed methods can not only generate preferred reproduction but also extract accurate color properties for industrial applications. The methods will be detailed in the final paper and two demos will be shown accordingly.

## Errors involved in profiles in color management systems

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### Abstract

Scanning an image by a profiled scanner, can not easily be interpreted by other operating systems. Therefore, it is usually recommended to convert the image profile into a device-independent profile such as sRGB (for RGB images) in order to be able to accurately perceive the correct colored image in all other operating systems. Several mathematical procedures must be performed on colored images, in order to convert the profile into a device independent profile which will obviously introduce errors in the results. The present paper, intends to calculate such errors for 2000 random samples in terms of calculated DE2000 color difference equation. The origins of such errors maybe as follows:

1. **Errors due to rounded decimal values:** since the sRGB image is converted to the AdobeRGB, the RGB values will be rounded of in the new profile and subsequently uncorrected values will be displayed. This effect can easily be demonstrated by converting a color image from one profile to another and then reverting the process to obtain the values in the origin profiles. Our result illustrate that the average errors due to this rounding decimal values equals 0.07 DE2000 units.
2. **Interpolation errors:** Interpolation procedures (either by a color management system and/or by an imaging software) is carried out in look up table profiles to predict unavailable values in such tables. Such interpolation procedures introduce errors in such predictions. For instance converting RGB values defined by a look up table profile to CIELAB values and the reverse process will produce different RGB values compared to the Original RGB. The errors in the created profile to be printed by an Epson P50 printer on glossy paper where converted from LAB to RGB and vice versa by this profile were determined to be 1.19, 0.86, 0.89 and 0.9 for the relative rendering intent, the absolute rendering intent, the saturated rendering intent and the perceptual rendering intent respectively.
3. **Errors due to out of gamut colors:** in converting an image rendered using a profile having a bigger gamut to a new profile with a smaller gamut, several colors will out of gamut in the new profile. Therefore, it is necessary to shift the out of gamut colors to be included in the new profile. This process will undoubtedly introduced errors. In switching from AdobeRGB having a bigger color gamut to sRGB having a smaller color gamut and the reverse process introduced an average error of 2.96 DE2000 units. Such mentioned errors illustrate that embedding a profile for displaying an image on another operating system, introduces less errors than converting the original profile to a device independent profile.

## Methods for assessing blackness

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### Abstract

#### Introduction

Blackness can be defined as a visual sensation according to which the object appears to exhibit more or less black content. It is included in the Natural Colour System (NCS) [1] and is an important attribute in the graphic art applications such as grey component removal, black point set up and image contrast. It is believed that the darker the black point of an imaging system, the higher image quality of the reproduction system. Tao [2] found that bluish blacks are more preferred than other tones of blacks having the same lightness.

The leading author has studied the attributes of vividness and saturation earlier [3]. This paper describes the study on scaling blackness as the third part of the research project.

#### Experimental Methods

A psychophysical experiment was carried out to assess blackness of 77 colour stimuli using categorical judgement method. Twenty Korean and 19 British observers participated in the experiment. Each observer gave responses on a six-point forced choice scale. The colour stimuli were selected from NCS atlas having 3x3 inch in size. Each colour was assessed twice during the experiment. Twenty colours randomly selected from 77 colours were assessed twice during the experiment under a D65 simulator in a VeriVide viewing cabinet. The mean scale value for each colour obtained from all observers was used for the subsequent data analysis.

#### Results

Intra- and inter- observer variability was calculated in terms of RMS: 0.95 and 1.04, respectively. A good agreement was found ( $R=0.94$ ) between the British and Korean observers. Thus the Korean and British results were combined to test NCS blackness scale and a new formula based on CIELAB was developed as given in equation 1.

$$\text{Blackness} = 3.02 - 0.05 \{(L^*)^2 + 0.89(a^*+2)^2 + 0.36(b^*-33)^2\}^{1/2} \quad (1)$$

The results of the models' performance are: 0.92 and 0.94 in terms of correlation coefficients for NCS and equation (1), respectively. This suggests that both the NCS and the new model can fit the experimental data quite well.

Equation 1 suggests that the further a dark colour deviates from  $(a^*, b^*)=(-2, 33)$ , corresponding to of 93 and of 33, the "blacker" the colour tends to appear. In other words, a black including a yellowish tint tends to appear less black than those having other hues, a finding that agrees well with Tao et al [2].



## Comparison of various whiteness formulae based on results of whiteness evaluation experiments

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### Abstract

Since there are great differences among observers in the criteria which are used to evaluate perceptual whiteness, in order to evaluate the predictive performances of whiteness formulae, it is desirable to make comparisons with results of experiments with large numbers of observers. In this paper, therefore, with the objective of selecting the whiteness formula with the best predictive performance, a study was made of the relationships between the values predicted by various whiteness formulae and the results of organized experiments carried out by the Committee on Specification Method of Whiteness of the Color Science Association of Japan and by the Special Interest Group on Whiteness of the society.

The Committee on Specification Method of Whiteness carried out the following three experiments in 1987 for the purpose of evaluating the CIE whiteness formula in order to formulate a JIS (Japanese Industrial Standards) standard: Evaluation of 18 types of white fabric samples by 74 observers; evaluation of 29 types of white paper samples by 74 observers; and evaluation of 47 samples combining white fabric samples and white paper samples by 46 observers. The observer groups were comprised of engineers from manufacturers in such industries as the paint, textile, paper, chemical and photographic film industries, researchers in a national research institution and researchers and students in a university. Our Special Interest Group on Whiteness carried out experiments in 2007 to evaluate 18 types of white fabric samples by 69 observers from Rochester Institute of Technology, USA, Joshibi University of Art and Design, and Kurashiki City College for the purpose of studying the relationship between the cultural background of observers and whiteness evaluation.

Whiteness formulae can be classified by their structure into five groups: a group using one of tristimulus values, a group using two or three tristimulus values, a group using a combination of lightness and chromaticness, a group evaluating on the basis of the color difference between a standard white and the sample, and a group of all other forms. Whiteness formulae corresponding to each group were selected, and a total of 16 different whiteness formulae including the CIE whiteness formula and the metric values associated with the samples were evaluated.

The simple correlation coefficient was determined between each of the results of visual evaluation and values predicted by the whiteness formulae in the three experiments by the Committee on Specification Method of Whiteness and in the experiment by the Special Interest Group on Whiteness. It was found, as a result of comparisons from the points of view of predictive performance, simplicity of calculation and scope of application, that the best formula is the Grum whiteness formula.



## A fast and accurate algorithm for calculating the color gamut boundary of multi-primary device

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### Abstract

In recent years, the displays trend towards large size, light weight, super thin, and small smart-phones applications. At the same time, accurate color reproduction is also highly desired. More recently, multi-primary color displays is becoming a development trend. Multi-primary color device easily provides a larger color gamut than the one of three primary device. Moreover the ability for truthful color reproduction is a major index to evaluate the quality of displays. In color mapping, we need to obtain the color gamut boundary (CGB) of displays. For the former technology of CGB, the data distribution for calculating the CGB of a reproduction device is not uniform, and then it causes some error in the implementation of color gamut mapping. This thesis proposes a general CGB theory of a multi-primary additive color system based on color mixing theory. It can determine the CGB by its apexes in CIE<sub>xyY</sub> space. When we obtain the *xyY* coordinates and their maximal brightness of the three or multiple primaries, the extremes of CGB in CIE *xy* color space can be determined directly. Then the uniform CGB in CIE LAB color space can transformed from CIE *xy* color space by inserting some color points between the extremes and adopting appropriate light sampling. This quick gamut boundary construction just needs both the multi-primary coordinates and their maximal brightness.

On the whole, the proposed approach can not only be used as a standard method for determining CGB, but also be applied into relevant color research such as displays and LED lighting design. Practical applications of this approach include the design of color volume, white point, and color temperature conversion for multiple primary color display and lighting. It also could have future impact on the development of detection of cross-talk characteristics, extending the usage of color appearance models, or color distribution index of display.

## Effects of diffusers on spectrophotometric properties of full color LED lightings

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### Abstract

In this work we measured and evaluated spectral characteristics of full color LED lighting sources with different diffusers and additional filtering materials to analyze effects of diffuser and other materials on the lighting spectrum. Recently, LED lighting sources are frequently used for general lighting and artistic media façade because LED has not only high energy efficiency but also various lighting color with different color temperature emitting phosphors and with different spectrum by the mixture of red, green, and blue LEDs.

LED usually has narrow bandwidth of wave spectrum and causes discomfort glare unlike conventional lightings. Two or three lighting sources with different phosphors are used to develop white LED with high color-rendering index and diffusers are used to reduce glares. In a previous work, color filters were used to improve colorimetric characteristics of white LEDs (Perales et al., 2011). We propose an alternative method to improve colorimetric quality and visual comfort using diffusers and additional filtering materials called Hanji (韓紙), a traditional Korean paper which is made from mulberry trees and is now being used as a filter for emotional LED lighting in industry.

We investigated physical characteristics of full color LED lightings, with red, green, and blue lighting source, affected by the combinations of diffusers and Hanji materials. In our preliminary experiment, two types of diffuser and four types of Hanji and their combinations were used. Spectral responses were measured using a spectrometer, CAS-140CT, and a 2-meter integrating sphere. Preference and naturalness of the lighting sources with the combinations of diffusers and Hanji are evaluated by human participants.

Experimental results show that spectrophotometric properties are modified not only by diffusers and but also by Hanji and the combination shows additive filtering effects. Optical simulation shows no change in spectrophotometric properties by diffusers. However, actual measurement shows different shift of primary colors in different diffusers. In addition, Hanji was very effective to modify spectrum. Especially, the unbalance of dominant wave length power spectrum in red, green, and blue lighting sources can be balanced better using Hanji than using diffusers. Consequently, the more balanced the dominant wavelength power is, the more natural lightings appear to human observers.

## Makeup color representation based on spectral characteristics

---

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### **Abstract**

Applications representing the makeup color on a skin image have sprung up in several device environments, such as a smart phone, mobile device and computer. They can be utilized for a commerce and medical treatment as well as beauty and arts. However, there is a gap between their results for makeup color representation and a real makeup color because the makeup color is represented without the consideration of the color interaction between skin color and cosmetics. In other words, the makeup color could not represent by simple color mixing rule in RGB color space. In real world, the light from illuminant is reflected to object, and the reflected light is recognized to human visual system. The recognized color is depended on spectral distribution of light and reflectance of object. Thus, to represent the real color, the spectrum characteristics of the illuminant and object should be considered. Therefore, this paper proposed the makeup color representation method using spectrum information of skin, cosmetics and illuminant. First of all, Camera characterization based on spectrum to obtain the reflectance image from a real skin is performed. Interrelation between measured spectral characteristics of color patches by a spectroradiometer and RGB values on captured image by digital camera is modeled through a linear or nonlinear process. Then, after capturing the object by the camera, the spectrum image could be generated by the spectral characterization model. Spectral information of cosmetics and illuminant is also obtained by measuring with a spectroradiometer. The transition of spectrum by the makeup process is estimated through the real makeup tests. Also, to represent the estimated spectral information on the display, a display characterization is processed. Input and output characteristics of display is modeled by measuring, and the spectral data is converted into RGB data reflected the color characteristics of display. These processes are applied to several skins and cosmetics under a standard illuminant, and the makeup color was more closed to the real color.

## **Influence of daylight illumination in principal components of natural images**

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### **Abstract**

It has been argued that the spatial color distribution in natural images can show statistic regularities in the color space. The distribution of luminance, color and local contrast in natural scenes has been quantitatively and qualitatively described elsewhere.[Hyvarinen et al., *Natural Image Statistics: A probabilistic approach to early computational vision*, Springer-Verlag, 2009] The purpose of this work was to study how changes in daylight illumination affect the Principal Components Analysis of natural irradiance and reflectance spectra.

The efficient information transmission in the Human Visual System (HVS) is achieved by a transformation of the response of the L-, M- and S-cones into an achromatic and two opponent chromatic channels.[W.S. Geisler, *Annual Review of Psychology*, 59,167-192 (2008)] The analysis of the spectral distribution of the sensitivities of the new channels shows that luminance channel is independent of the illuminant but chromatic channels have a clear dependence on the CCT of the illuminant. The opponent channel red-green has the strongest dependence and the results are emphasized when a previous von Kries chromatic adaptation is considered.

Principal Components were also computed from different hyperspectral images of natural scenes rendered with daylights of CCT from (5,500 K to 7,500 K; only four eigenvectors were needed to obtain more than 99.5 % of the information carried by those signals.[Hernández-Andrés et al., *Journal of the Optical Society of America A* 18, 1325-1335 (2001)] Using four eigenvectors, which account for more than 99.5% of the variance of the data, principal components were analyzed for a representative set of natural image pixels as the CCT changed. In addition, an equienergy illuminant was used to obtain the ratio constancy of the response of those principal components. Strong correlations for all CCTs were found for the first and the third component. The correlations of the coefficients for the second and the fourth components were significant in a reduced rank of CCTs (below 6,199K and above 6,699 K for the second and fourth components, respectively). Finally, the plots of the slopes of the previous linear adjustments with the CCTs of the illuminants show that only a linear model to fit them is possible for the second principal component in the CCTs rank where the adjustment was significant.

## How blue is the blue and white porcelain? - A study of the color characteristics on blue and white porcelain by using spectral imaging technology

---

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### Abstract

The popularity of blue and white porcelain spans for several centuries and regions. The shapes and patterns of the blue and white porcelain can be different from different regions. Even though cobalt oxide pigment is mostly used for the blue color, the blue color appears differently among various blue and white wares. It is of curiosity that how different is the blue color on them? Is it possible to analyze and then identify the blue color without contacting, nor scratching the porcelain?

This research deploys spectral imaging technology to capture the color image of the blue and white porcelain. An achromatic CCD camera configured with a spectrograph element on a X-Y scan-bed is used to record the spectral color information in the visible bandwidth. Each of the image pixel is recorded not in a regular RGB tri-chromatic format but a vector of principal component composition from sampling the object reflectance in spectral resolution of 10 nm in the visible wavelength. These vectors represent the spectral reflectance information on the material showing the color characteristics of the blue color which can be computed with CIE color matching functions into CIELAB values. Further analysis can be done in hue, lightness and chroma etc. It is then possible to compare the blue color quantitatively for the blue and white porcelains. The simulation for how the porcelain appears under various illumination is also possible since the reflectance of the object is stored in spectral form. The blue and white porcelains from different centuries collected by Hwa-Kang museum are the primary objects under investigation in this research. It is intended to establish a method to archive and analyze the color characteristics of the blue and white porcelain using a spectral imaging technology. The resulting analysis for the color characteristics of the collected blue and white porcelains will be presented.

## Correcting for non-uniform illumination when photographing the mural In the royal tomb of amenophis iii (iv) applying huge mural images

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### Abstract

We are attempting to digitize the mural at the royal tomb of Amenophis III. When photographing the mural, two strobe lights with umbrellas were used to provide uniform illumination. Nonetheless, the illumination was still somewhat non-uniform. To correct such a non-uniform illumination, we developed a new illumination model, in which a strobe and an umbrella were assumed as a point light source located at a long distance. The point light source model was confirmed by using images with white patches and images of the model mural without white patches (Proceedings of AIC 2011, p.467).

We attempted to apply the model to huge mural images which were about 500 mega pixels 16 bits TIFF images. As library soft wares, e.g. Open CV, do not support such huge images, we coded a program in which the RGB data of raw images were processed by line by line. At first auto extraction of backgrounds was tried, but backgrounds could not be extracted. Then uniform backgrounds were extracted manually, and digital counts RGB of the back grounds were extracted. The constants employed in the model were computed from these digital counts. Then non-uniform illumination of mural images were corrected by using the model. The corrected images were observed as more uniformly illuminated.

For a comparison we used two dimensional second order polynomial, which were used to non-uniform illumination model and trend removal, to correction of non-uniform illumination. As a result, averages of standard deviation of tristimulus values Y of backgrounds are 0.0322, 0.0116 and 0.0137 for original images, corrected images by the using the point light source model which we developed and the second order polynomial model, respectively. The point light source model was slightly superior than the other.



## The synthesis and properties of 3-(1'h-benzimidazol-2'-yl)-Coumarin fluorescent dyes for polyester fabrics

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### Abstract

Coumarin compounds which are widely distributed in plants are good fluorescent materials hold excellent optical properties. Coumarin was one of the materials that were the first found to contain fluorescence. Fluorescent dyes possess a very special structure that consist of double bond conjugate system and planar structure. Many coumarin dyes and their derivatives are of great practical interest; they are used widely as optical brighteners and as fluorescent dyes for textile materials. And introducing different types of substituted group in the 3- position or 7-position or both 3- or 7-position of coumarin ring will increase its fluorescence.

Fluorescent dyes based on 3-(1'H-benzimidazol-2'-yl)coumarin were synthesized by a simple reaction in this study. The chemical structures of synthesized compounds were subjected to FT-IR, <sup>1</sup>H-NMR, Mass and UV/Vis analysis for color characteristics. Polyester fabrics dyed with the compounds were evaluated by color strength and color fastness to washing, perspiration and light of ISO. The results showed that synthesized compounds were identified by IR, MS and <sup>1</sup>H-NMR. And then they were used to the dyeing of polyester fabrics. It was clearly that color strength increased with the increasing of the amount of carbon in the seventh location of coumarin ring. The level of color fastness to washing and perspiration were 4-5 or more, while the level of color fastness to light decreased with an increase of carbon chain length.

## Interaction of color-pigment and color-light for set design: studying a tool for cmyk and rgb color systems

---

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### Abstract

This research aims to study the interaction of color for set design. On stage, the set design surfaces are painted (pigment colors) and illuminated by artificial and colored light from projectors while the environment is dark. We consider both RGB light and CMYK color systems to study a tool to simulate this interaction. The approach involves two key moments: (i) Color spectrum analysis of “apparent color” by the combination of the additive and subtractive color systems (RGB and CMYK); (ii) Creation of an application to simulate the apparent color resulting from the combination of the RGB and CMYK systems, graphical diagram and systematic observation, recording and analyzing the phenomenon on stage. The main goal of this study is to clarify and understand the interaction of color (light and matter) as well as its relevance on stage. After testing and showing the relevance of these tools, the next step of research should focus on their development as a support for design thinking process. The lack of specific studies makes this research relevant.

## Colour absorption equation as instrumental tool of light research.

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### **Abstract**

Nature of colour is defined as the selective absorption of light. Light once generated, penetrate the space undergoing the acts of absorption and reflection in air, to water, dust, and chemical conglomerations. Natural colour structures are well known as the clouds of the atmosphere, oceanic water reflections, and the wheel of rainbow. Chemical substances are responsible for the absorption of light. Important physical law of colour absorption of the light: light partially reflected by pigment, partially absorb on the components of pigment. Pigment as chemical structure on the way of light is the mixture of separate substances. The general main physical specification of the spreading of the light through world is the acts of absorption and reflection. Since this is physical process, we can quantitatively describe and calculate the properties of one or other pigment or another selectively absorb and reflect light. Selective luminous absorption by the mixture of coloured pigments is given by the system of three equations: 1. equal coloured pigments absorb the equal parts of the light, 2. the brightness of reflected light are equal to the superposition of the partial brightness's of the mixture of coloured pigments, 3. selective colour absorption is the result of the superposition of the luminous absorption of the partial components of coloured mixture. The law of selective light absorption of colour in general makes it possible to uniquely determine colour and quantity of colour pigments. In work spreading of the substance being investigated as the distribution of coloured pigment, in the comparison with the known standard pigments, as well as a natural colour rainbow wheel. The surface of colour mixing with the characteristic lines of colour, brightness further adapts for mathematical computation of the spatial spreading of colour pigment in the assigned substratum. Instrument task consists of the graphic measurement of the process of distributing the assigned substance. The extended task of investigating the industrial processes of the ejection toxic substances into the natural landscape is examined.

## A new path to introduce the color theory to basic design studio: impressionism as a source

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### Abstract

As very well known, Basic Design is an introductory course offered in the first year of the curriculum in art and design education. As a course basically focusing on visual perception, principles of basic structures, form-function relationship, color theory and composition, it is an open ground for different approaches in introducing the color theory.

This study focuses on a specific method to introduce the color theory in Basic Design Studio. It is based on a series of exercises in 2011 Fall Semester that was conducted in Basic Design I in the Department of Industrial Product Design at Istanbul Technical University (ITU), Turkey. Impressionism, one of the influential 19<sup>th</sup> century art movements, is the inspiring basis for these exercises because of its special attention to color and light not as objective facts, but relative and experimental issues.

Basically, the exercise has three stages; analysis of the color composition, re-interpretation of the composition and transformation to 3D. In the first stage, students are required to discover and learn what Impressionism is and choose an Impressionist painting for their work. They are required to analyze the painting by focusing on its color composition. They have to make an abstraction focusing on the dominant colors in the composition and the way they are structured on the surface of painting. Students are able to experience the certain hues by mixing red, blue and yellow. They can also add black and white to get the shades or tints of a hue. Therefore, it has been an experiential and informative stage while discovering the elements of a hue. In the second stage of the exercise, students have to re-interpret the color combination in the light of color theory after they are briefly introduced with theoretical background. In the re-interpretation stage, students mostly prefer to use the contrast colors and try to reverse the effect of the composition. In the last stage, students are asked to transform the Impressionist painting into a 3D form by using tetrahedrons, considering the color combination as a source of volumetric and spatial understanding. In this stage, they often make abstraction of the dominant part of the painting.

As color is a primary element in both art and design education in general, it is important to mention about the special position of it in terms of industrial design education. In classical understanding, color is regarded as connected to the aesthetics of an object. However, as this exercise suggests, the abstraction and transfer of the color into a self-standing 3D structure challenges a new transfer. That is of visual dynamics into a coherent physical function, which is the premature phase of form supporting utility in design. Abstraction is the source of alienation towards the form and function, in which new formulas can be created in terms of structure, utility and aesthetics.

This paper includes stages of the formation, processing and the evaluation of the mentioned exercise. Exercises are exemplified in a detailed way to help reveal the issue and process thoroughly.

## Teaching aids about mixed colors - Color by mixed spinning of dyed wool fiber

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### Abstract

Although many textiles are used for our personal appearance, there are few opportunities for us to get to know the production process of textiles with the most ready-made articles. Spin wool into thread has processes, such as washing, dyeing, and silk thread spun. The thread spun by hand is available to make textile goods, so the using such a thread for the teaching aids makes it possible to learn experience about the textile. Our information from outside environment depends commonly on the vision. Especially color has played important role. When we product textiles as teaching aids, various expressions are attained by adopting various color, and a student's volition is made high by it. However, it is difficult to prepare the dyed wool of various colors at one school.

This research examined the teaching aids which made various colors by mixing the dyed wool. The wool used in this research is the Cori Dale bred at the Rokkousan Pasture of Kobe City in Japan. The yield of the raw wool of 1 kg was set to about 700 g by washing treatment. The wool was dyed in three colors by using the acid dye solution (pH 4). Names of those dyes are DERUKUSU red F-5G, DERUKUSU B. yellow S-GB, and DERUKUSU B. blue BG, respectively. The average degree of pigmentation of the wool dyed by acid dye was 98%. As for colorimetric quantity of the wool after dyeing, it is in red  $L^*=43.1$ ,  $a^*=46.2$ , and  $b^*=36.2$ , in yellow  $L^*=73.3$ ,  $a^*=-4.5$ ,  $b^*=67.6$ , and in blue  $L^*=43.9$ ,  $a^*=-36.5$ , and  $b^*=-21.6$ . Incidentally colorimetric quantity of raw wool was  $L^*=75.0$  and  $a^*=-0.13$  and  $b^*=12.1$ . The wool dyed in three colors was blended by carding, and the result of the changed color was considered. Three kinds of methods were used for carding. In the first method we mixed two colors at a time from red, yellow and blue wool. Woolen weight was changed to 1:3, 1:1 and 3:1 in this case. In the second method the wool of red, yellow, and blue was blended to 1:1:1. And then the each wool in three colors was blended with the wool before dyeing by 1:1 as the third method. When the colors of the dyed wool were mixed by blending, the aggregate of the fiber was obtained where the wool fiber of each color before blending is distributed equally. The aggregate of this dyed wool is classified into the juxtapositional color mixture. Although it was difficult to make color of high chromatic saturation compared with the dyed wool before blending, various colors could be made by the blending of the dyed wool. The teaching aids that the learning students dye and blend the wool regarding the ratio of a color suggested it in the production process that it was useful also for study of other subjects, such as science and fine arts.

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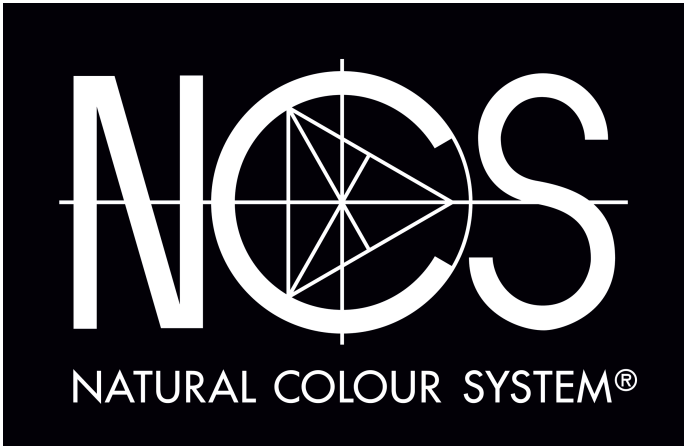


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