# aic

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# 2011
**SWITZERLAND**

# Interaction of Colour & Light
## in the Arts and Sciences

Midterm Meeting of the
International Colour Association (AIC)
7–10 June 2011
Zurich, Switzerland

# Book of Abstracts
Conference Proceedings on CD

Editors: Verena M. Schindler, Stephan Cuber

*pro/colore*
Schweizerische Vereinigung für die Farbe

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

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# Contents

# AIC 2011

The beginnings of the AIC 2011 Conference in Zurich, Switzerland, occurred during a visit to the Alhambra for the 10th AIC Congress in Granada Spain in 2005. A small Swiss group began discussions there and then successfully prepared – together with the members of the AIC 2011 Organising Committee – an exciting programme on the theme of the 'Interaction of Colour & Light in the Arts and Sciences.' At AIC 2011, which will take place from June 7–10, a total of forty-five oral papers, three invited lectures and one Judd Award lecture will be given. As well, 150 posters will be presented in two successive poster exhibits and discussed during the poster sessions.

I would like to thank the members of the AIC 2011 International Scientific Committee for reviewing the 325 submissions. The devotion and hard work of the AIC 2011 Organising Committee ensured that this adventure has turned out to be a great success. It is perhaps the first time that an AIC Midterm Meeting has been fully booked by the early registration deadline with 290 participants from almost forty countries working in many different research fields.

As for the social programme, a welcome reception at Zurich University of the Arts (ZHdK) and conference dinner at the 'Zunfthaus zur Meisen' provide an opportunity for the participants to get to know each other and develop an exchange and network. As well, an excursion exploring new urban development and colour planning in Zurich that has been organised by Haus der Farbe Zurich is an optional event open to all AIC 2011 participants and accompanying guests. Further a walking tour to experience the historic city core and its plan lumière has been organised by NCS Colour Centre Schweiz, one of our main sponsors.

I would like to extend my warmest thanks to our partner, sponsors and supporters for their generosity; their precious support has made this conference a successful endeavour.

I wish you all a captivating AIC 2011 Midterm Meeting and an exciting time in Zurich!

Verena M. Schindler,
AIC 2011 General Conference Chair

www.aic2011.org

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The Swiss Colour Association pro/colore is an independent, non-profit colour association that aims to serve as a general and professional platform for dealing with colour design, dyes, colour reproduction and colour communication. pro/colore is actively dedicated to promoting more conscious ways of understanding and dealing with colour, not only in the way it is used creatively, but also in terms of its production and reproduction.

Collective and individual membership is open to affiliates of trade unions and companies, educational, public and professional organisations and institutions, as well as private persons. Currently pro/colore has more than 300 members. pro/colore organizes colour events four times a year. On these occasions it sends out a letter including a whole range of information on colour and colour events to its individual and collective members.

The main goals are to further the exchange of experience, spread information and support cooperation between members of different specialization. A further aim is also to encourage international cooperation and exchange with other colour associations, e.g., the German colour association Deutsches Farbenzentrum. As well, pro/colore is a member of the International Colour Association (AIC) being one of the signatories of the founding act of the AIC in 1967.

www.procolore.ch

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Schweizerische / Vereinigung für die Farbe
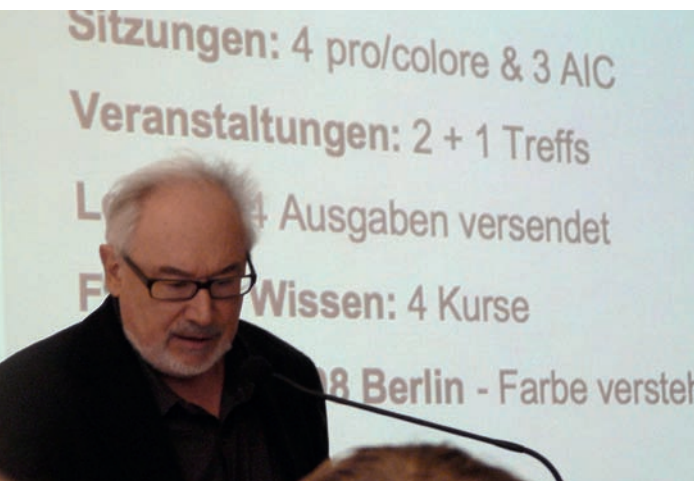
# Interaction of Colour & Light in the Arts and Sciences

How do coloured surfaces change their appearance with coloured light? How does light interact with materials? How does light interact with colours in our environment, on stage, on digital screens and in daily life? Do we have tools to teach about the interaction of colour and light? How can we best explore the effects of the interaction of light and colour in relation to people? The fields of inquiry include education, design, art, media, lighting, theatre, architecture, urbanism, and landscaping as well as psychology, colour science and technology. The AIC 2011 Midterm Meeting in Zurich that will take place from June 7–10 aims to further discussion and nurture the latest findings in these various fields from both theoretical and practical points of view.

The AIC 2011 conference presentations demonstrate the productive nature of the theme of the Interaction of Colour & Light in the Arts and Sciences. The papers explore these important topics in today's scientific and artistic research communities. New technologies, materials and media are now being deployed to enhance, alter and improve our experience in real and virtual environments.

**Conference Topics and Sub-Topics**
Submissions were accepted for consideration in any of the topics mentioned below.
**1. SPACE:** a. visual culture; b. photography; c. design; d. lighting; e. interior architecture; f. architecture; g. urbanism; h. environment; i. landscaping; j. visionary projects
**2. STAGE:** a. performance; b. art; c. museography; d. scenography; e. techniques of staging; f. theatre, performing body; g. dance, movement; h. music, sound; i. virtual projects
**3. EDUCATION:** a. teaching aids; b. methodology; c. theory; d. terminology; e. static and electronic media; f. multimedia
**4. PSYCHOLOGY:** a. colour perception; b. harmonious interactions; c. emotional interactions; d. illusions resulting through light and colour interaction
**5. SCIENCE & TECHNOLOGY:** a. colour science; b. physiology and psychophysics; c. colour appearance and measurement; d. materiality, texture, surface; e. transparency and translucency, reflection and glossiness
**6. COMPUTER GRAPHICS:** a. colour in computer vision; b. colour in graphic design; c. multimedia in colour imaging; d. computer graphics scene rendering; e. Virtual Reality (VR) and Augmented Reality (AR) environments
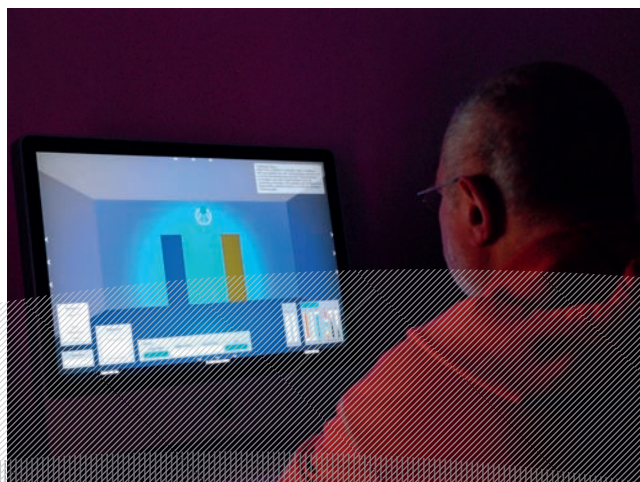
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# Judd Award lecture

# Experimentation in colour vision

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## Abstract

The present paper deals with the evolution of visual psychophysical research since 1950 on. At that time, a world Task Force was activated to raise the Physiological Optics (later Visual Science) to the official level of a multidisciplinary branch of science, on particular by including Physics through Optics. Briefly, the visual system, regarded as a physical system, was compared to a 'closed box' regulated by laws, defined the relations between input and output signals (that is, the observer's responses, obtained by using the psychophysical methods). Two simultaneous research channels were active.

The traditional channel was devoted to recording the basic laws of visual functionality by using simple, local rigidly controlled stimuli (small, simple), were varied each at a time, the others (parameters) being 'frosted', and by rigidly controlling also all the observer related, and environment related conditions. In the fifties the visual system was considered more sensitive than any man-made detector, therefore, several experiments were devoted to the dependencies of both achromatic and chromatic thresholds (by varying stimulus wavelength and spectral composition). Color vision was also in relation with colorimetry, and two centuries elapsed to release trichromacy itself from the demand of accounting for color appearance. The aesthetical value of color (even regarded 'as a luxury') belonged to Psychology. The basic laws of functionality, formulated under the agreement of various laboratories, were utilized in applied fields (e.g. by CIE for lighting). The traditional channel was subsequently modified in various subsequent ways, but it did not solve the problem of the combination of the single variable functions to get the behavioral response.

The other channel of psychophysical research, operating in parallel, was involved, in the alternative task of creating the computer assisted, spatially non-uniform test objects. In particular, a large number of color variations and of luminance variations were obtained, alone or in combination. Later, their use led to the color specific luminance coding. Julesz, Barlow, Caelli traced the way to the recent transition from simple to complex. In fact, driven by pioneering concepts like feature extraction, and in the presence of variable textures, the responses to their new stimuli represented the basis for the study of global responses. All it was in line with the subsequent modeling based on feature conjunctions, inter-feature interactions (involving super-additivity or sub-additivity, counteraction or compensation, facilitation or inhibition, assimilation or contrast), preceding the internal representation, modulated by higher centers, till the WTA [Winners takes all] (decision center). Starting from the traditional functionality laws, the global responses cannot be calculated, because the mutual inter-feature interactions are not included. Nowadays various authors are experimenting with the advantages of conjoining an increasing number of features, to attain a prediction of a global response similar at most to the human responsivity. The major effects are created when introducing the texture as well as coping with the fact that traditional photo-colorimetry was created for spatially uniform surfaces.

Our personal research is oriented along the lines described above. Data are reported about

the peculiar effects observed across the range where the vision of textured targets is uncertain, with reference also to the use of LEDs as traffic signals and related claims. Other data concern bilateral symmetry, by using as global response the balance, or match of visual weights, for paired samples with different amounts of information, by conjoining color, luminance and texture and feature contrasts. At last, some data concerning the possible influence of the 'color of the light' on human circadiancy (global response) are presented, by considering the ventilated initiating role of the ipRGC ganglion cell of the retina of mice... To conclude, the problem of up-to-dating the beginners, going beyond the educational courses yet exclusively relying on traditional notions is discussed.

## Lucia Ronchi's biography

Lucia Ronchi, after a doctorship in Physics, at the University of Florence (Italy) has been devoting her activity at the INO (National Institute of Optics), which, in 1950 was included in the list of the Laboratories (one per nation) involved in a world project: to bring the Physiological Optics (later Visual Science) to the official level of a self standing discipline. Since the study of vision is multidisciplinary, it was necessary to contact the converging branches of science, to select the concepts of interest and to create annotated glossaries. Two research approaches were begun in 1950. In addition to being involved the traditional one, devoted to the formulation of the basic laws of visual functionality and its applications, Lucia Ronchi also followed the simultaneous advanced approach involved in the study of textured and complex patterns. Accordingly, when at the end of the 20th century the former approach had practically completed its task, "in the captivity of the laboratory", it was easy the full immersion in the treatment of the complexity of the real world and in the "jungle" of the Natural environment with the support of computational modeling. While traditionally color was a sort of luxury, a matter for Psychologists, at the end of the century color has abandoned its gregariousness. The color feature is now extracted with luminance and orientation by the first order vision, and, passing to the second order vision, it conjoins with every other feature, but color does not obey to the same rules, it is independent and the distinction between chromatic and achromatic vision is practically lost. Lucia Ronchi is now working by looking for new global responses, and trying to organize an educational program appropriate to the "cultural revolution" of the third Millennium.
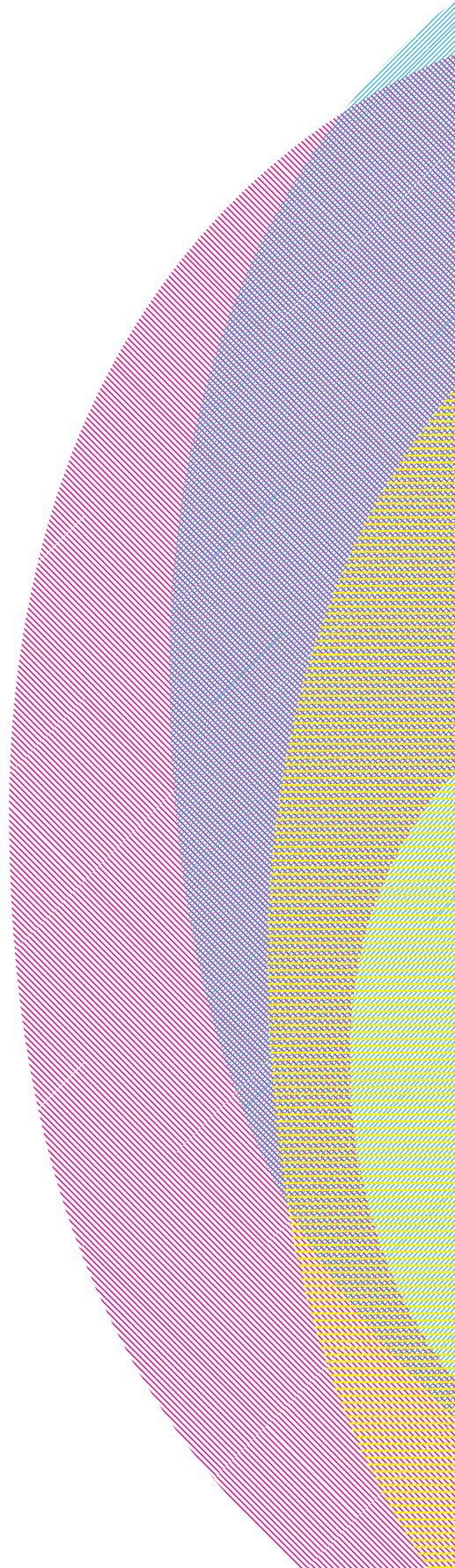
# Invited lectures, oral papers

in order of presentation

# From colour light research to colour light teaching

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## Abstract

The many different interactions between light and colours represent very important research topics towards new teaching developments and practical applications in art, architecture, design and performing arts. Our main questions were:

– How are the effects of colours influenced by dynamic lights?
– What are appropriate elements for teaching the complex interactions of colour and light and how do they have to be designed?
– What is the relevance of the developed materials regarding teaching and practical use?

The above aims were achieved by practical experiments and evaluation following the idea of research through design. The design driven experiments included specific light and colour measurements and were combined with specific evaluation methods. Our findings show:

– The relevance of hue shifts using coloured or different white light sources concerning different practical applications
– The necessity of using differentiated materials in colour and light teaching
– The relevance of the developed materials for experts in the field of colour teaching as well as in the fields of art, architecture, design and performing arts

Following materials were developed: Room installations, interactive models, digital tools, the multimedia publication *Colour and Light: Teaching Materials* including the documentations of our research projects.

After showing the relevance of our teaching materials, the next step of research should focus on the development of instruments supporting various design processes in the field of colour and light.

# Interaction of colour and light: Simulation and assessment under artificial and natural light

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## Abstract

The interaction of colour and light is of significance for architecture, design and art. This paper focuses on the question of how to systematically analyze and describe the interaction of sunlight and colour (a) in outdoor settings and (b) under the conditions of an 'Artificial Sky' – a sunlight simulation laboratory at the Department for Building and Environment at the Danube University Krems, Austria.

**Outdoor settings, light, colour and shadow:** The essential challenge but also most interesting aspect of systematic research of the interaction of sunlight and colour under natural conditions is continuous alteration. As a result of Earth's rotation and orbit around the sun the angle of incidence of light changes continuously. As a consequence not only the illumination changes but also the position and size of shadows. These changes do not occur at a steady pace. The speed of transformation varies considerably depending on the geographical position, season and time of day.

To observe objects and models in different environments I constructed a portable modular laboratory consisting of a turntable, gnomons and goniometers to measure solar altitude and azimuth. Once the table was set up and the models arranged a DSLR-camera was mounted on a tripod and connected to a remote interval timer. Every five minutes one exposure was taken. A second hand-held DSLR-camera was used for additional shots from different viewing angles and distances. The models (and surroundings) were observed with binoculars and the naked eye. The colours and their subtle transitions throughout the day were assessed visually with reference to NCS (atlas and index). Sun path data and diagrams for the exact geographical position of the experimental sites were obtained and linked with the time code of the photographs. Photographs were analysed individually and in animated succession.

**Simulation of daylight illumination and colour in the Artificial Sky:** The Artificial Sky at the Danube University Krems permits a simulation of external natural lighting conditions at any location, season and time of day. It is a combination of a sky dome fitted with 230 colour-filtered halogen lamps and a mobile, artificial sun – consisting of a 1000 W halogen lamp with a parabolic mirror. In order to understand better to what extend the effects of the interaction of sunlight and colour can be simulated, some of the outdoor experiments were repeated in the Artificial Sky and their findings compared with those of the first study.

**Conclusion:** Both methods are useful for analyzing and describing the interaction of sunlight and colour. The quality of outdoor settings (clear sky conditions), however, cannot be achieved under the Artificial Sky. Colour rendering and shadows appear quite different. Subtle transitions and temporal effects are difficult to reproduce. Colours have to be assessed in isolation, as there is no possibility to observe the setting in relation to any (natural) surrounding. On the other hand in outdoor settings the apparent movement of the sun cannot be stopped.

# Coloured light sequences based on human perception: The case of a lit sculpture in an urban open space

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## Abstract

A research regarding coloured light sequences was conducted on the occasion of the author's design of a coloured lit pyramidal sculpture. This sculpture is composed of 44 "V" shaped moduli painted white matte and tilted. The latter are individually fixed on thin poles. More specifically, the moduli are staged on 8 levels. They are fixed on a circular base along a mesh of interlaced spirals. The structure has 6.0 meters of total height and is lit by RGB LED uplights inserted into the base.

The goal of this inquiry was to develop design strategies and methodologies that meet the requirements and specificities of spatial-temporal sequences by means of coloured lights. In this way, four aspects such as light, colour, space and time were studied respectively in order to identify the priorities for any further research.

First, the RGB light source values were assessed in order to define the specific codes for the three primary colours on a 0-255 level scale. Subsequently, these were altered based on the assessment of the colours on a sample modulus of the final structure, manipulating each of the RGB components respectively.

Second, the colour palette was observed as a whole. Noticeable discrepancies were noticed among the subsequent colour gradients. Consequently, the RGB codes were critically assessed and altered in order to render this colour palette seemingly more continuous. Furthermore, previously determined relative luminance sensation values were used in combination with the cube-root chromatic adaptation in order to redesign the RGB coding.

On site experiments hinted towards the avoidance of the feeling of repetition. By accentuating the perception of primary colours, an illusion of a temporal continuous flow is induced. The experiments also showed the importance of observer's point of view in designing 3D coloured light sequences in relation to the spatial organization and segmentation based on the visual scenes.

In sum, both, empirical and theoretical, research allured to the importance of design methodologies of coloured light sequences based on the user's visual perception in relation to the temporal and spatial context. Considering the temporal aspect, further improvements could be done by integrating colour remanence, both in discontinuous phases and in continuous gradients. Regarding the spatial dimension, further inquiries should be conducted on visual attractiveness of hues under mesopic conditions with a non homogeneous vision field, referring to the Esterman grid, for instance. The last area of inquiry is strongly connected to an ongoing personal research concerning both, the aspect of night vision as well as that of the visual scenes in an urban environment.

# RGB colours, kinetic traces, body, and space: An exploration of the narrative potential of the interaction of light and colour in the performing arts

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## Abstract

Performing artists, such as dancers and actors, will greatly benefit from the understanding of the systematic effects caused by the interaction of luminous and pigment-based colours in the conception and execution of their works, specifically the potential metaphors and narratives that can be derived from this interaction. The purpose of the research was to understand how the change of the colour appearance of an outfit worn by a dancer based on luminous and pigment-based colour superimpositions could impact a performance narrative when using a technique called *Kinetic Traces* —where a programmed keyboard triggers different brushstroke styles and colours, and deploys fading effects and transitions. In *Kinetic Traces* "drawings" created by an artist are projected on the dancers and the space in real-time. During improvisations, dancers may respond to the drawings, and vice‑versa, building sequences of actions and reactions. At other times, drawing and dancers co-exist without interaction. For this research studies were conducted, in which luminous colours predefined in RGB values were tested against red and green outfits. During a workshop at the III International Seminar About Dance, Theater and Performance, UFBA, Brazil, participants choreographed and performed a dance study titled *Kinetic Traces: Dreamscapes* (2010), comprising a sequence executed that explores the interaction of additive and subtractive colours (video documentation is available online). The sequence showed that by projecting a frontal luminous colour of a specific hue on a dancer, the colour of the costume was purposefully turned into a dark gray to produce a "single body" effect composed of the dancer and her shadow. The group believed that this effect added a new meaning to the sequence. Overall, during the studies we observed that the colour of the costume could change systematically based on the colours being projected; it was possible to achieve subtle and abrupt colour changes in the costumes; and most importantly, the impact of luminous colour on the colour of the outfit added a new expressive dimension to the performance. This research suggests that the understanding and systematic manipulation of the interaction of luminous and pigment-based colours has the potential to impact the development of a new set of expressive tools for the performance arts, such as dance and theatre.

# Altered space: The transformative capabilities of colour and light in the architecture of Steven Holl and UN Studio

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## Abstract

The paper is part of ongoing research by the author into the use of colour as an integral tool in architectural design. The author, both practitioner and teacher, has been aware of a lack of discussion of colour in much of mainstream architectural education in the UK, and a concomitant pervading anxiety in the use of colour by many architects. The research is therefore practice-led, and started with an analysis of the use of pigment and pigmented materials in contemporary architecture. The aim of the research is to consider underlying principles that guide the integration of colour at the conceptual design stage, as opposed to the more common, and somewhat arbitrary, application of colour in the latter stages of architectural projects. The original research has been based on a series of semi-structured interviews with contemporary architects whose work demonstrates a confident use of colour. Conventional theoretical research ran in parallel with the interviews, and has been used to tease out key thematic approaches to the use of colour.

The research exposed the growth in the use of coloured light in architectural design, either projected onto surfaces as computer controlled pulses, generating complex patterns, or using reflected light to infect space. Coloured light, whether projected or reflected, requires none of the commitment of embedded pigment, and has released architects to experiment with colour, surface and space.

This paper will explore the transformative capabilities of colour and light in architecture through selected projects of two contemporary architectural practices. Colour, which is generated through the play of light, even more so than embedded pigment, is never static and has the capability to be used as an instrument to tune and transform architectural space. Although coloured glass has been used for centuries, casting tinted shadows across surfaces, this phenomenon is largely a side-effect rather than the primary intent. Drawing on an interview with Ben van Berkel and Caroline Bos of UN Studio, based in Amsterdam, and considering the work of the American architect, Steven Holl, the paper argues that the metaphysical properties of reflected colour can be seen as instrumental to a synergic design of architectural space.

# Architectural glass colour palette

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## Abstract

Nowadays, coloured glass is more and more frequently used as a major façade material. However, it is not that easy to choose the right glass colour. First of all, we don't have a sufficiently varied colour spectrum. It mainly includes blue, grey and green hues. Secondly, there is no single colour classification available for transparent materials and we have to use descriptive names. As a result, glass colours with very similar names and appearance have absolutely different physical parameters and give different effects on facades. Therefore, the objective of our study has been to develop a scientifically grounded architectural glass colour palette based on such physical parameters of measurement as transparency, chromaticity and light transmission. This palette will allow architects and manufacturers to have a single communication tool/a common language in selecting and ordering glass

Having analyzed the existing colour coding systems in different areas of applications we have concluded that most of them cannot be applied in determining and measuring light characteristics of transparent objects whose optical parameters are of particular importance.

They include, in the first place, light reflection, light transmission, colour, solar radiation transmission, a shading coefficient, a heat transfer coefficient, heat-transfer resistance, emission factor, etc. Thus, the presentation will focus on the CIELAB model (L*a*b*) as most adjusted for developing the palette and architectural glass identification. In line with the selected procedure we have measured the main glass light parameters: external and internal reflection indices, light transmission of architectural glasses different in colour, thickness and light and thermal transmission properties.

The presentation will demonstrate the spectrophotometric method for measuring colour coordinates and a glass reflection coefficient. This method enables to imitate different ways of illumination and different types of perception.

The proposed palette and colour identification codes for architectural and construction glass comprising of 372 colours in various colour areas, is a result of the three year collaboration between the Moscow Colour City Centre and the Asahi Glass Company (Glaverbel-Vostok) Russia. This palette most fully corresponds to the market needs and meets the preference of most demanding designers and customers.

# Interstices of colour and light in the architectural and pictorial space of Venice

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## Abstract

This paper analyses the interstices of colour and light when part of the architectural and pictorial space of Venice, in search of potential connections that may enable a fuller awareness of space-light-colour dynamics phenomena.

In the Middle Ages and Renaissance, the Republic of Venice was a maritime and mercantile power, that acted as a crossroad between East and West. The expansion of trade and commerce provided the Republic with access to art, technological solutions and materials from all parts of the world. However, not having the possibility of physically expand, Venice grew in opulence, luxury and shimmer. Exposed to a multiplicity of ideas that were continually exchanged, a cultural fusion took place and is well revealed, for instance, in the harmonious cohabitation of Byzantine and Islamic architectural designs and the Gothic and Renaissance palaces. It is the underlying assumption of this study that the trading port of Venice was the cradle for the development of its beauty, wealth, exuberance and refinement, but it is in the colourlight multidimensional interactions with spatial concepts, that the singularity and uniqueness of this place is found.

Supported by the Lisbon Technical University and originated at the Faculty of Architecture LABCOR- Colour Lab, this phase of the research project provides a layer of 'exploratory embryonic clusters' to be followed by a set of 'integrative clusters' derived from a cross-comparative analysis between the indicators of convergence of meaning that are expected to emerge.

The results of this initial phase of the research project indicate a set of 'embryonic clusters' construed using exploratory methods that interweave field data gathering techniques such as *in situ* sketches, photography and film, with the grounded analysis of the *spatial constituents* and their interactions with the *dynamic agents of colour and light* in the (1) city's overall environment and settings; (2) features of structure, organization and surface in architectural settings; (3) representation of space, colour and light in a selected group of paintings- the Venetian *colorito* - where parallels between pictorial space and architectural space are found: Gentille Bellini Guardi, Veronese, Canaletto Titian, Carpaccio, Mantegna; (4) consequences of light on the texture and *tessitura* of mosaics, tiles, glass, textiles, and pigments when part of either architectural or pictorial space or in comparison to each other; (5) physical and cultural grounds for the interpretation of interrelations between light-colour-space; (6) qualities of illumination on the 'liquid space' and its consequences on solid space and the space of creative imagination. Running in parallel, the exploratory referents of the study are structured with sources coming from the fields of history of art, light and colour theory, aesthetics, visual perception, art and architecture.

# The colour space of Zurich. An exemplary research on colour, texture and light in urban space

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## Abstract

What are the colours of Zurich? This simple question, raised by the city's department of urban planning in order to establish a well-founded basis for colour decisions in urban settings was the beginning of a five-year research, conceived and directed by Haus der Farbe in co-operation with the municipality of Zurich and CRB-NCS Colour Centre, Switzerland. In the face of the city's participatory policy in decision-making the purpose of the project was rather to increase the competence of all actors dealing with colour in the urban space than to establish regulating instruments such as chromatic charts or a colour master plan.

Hence working tools were developed which are valuable both for the public authorities as well as for architects, colourists, craftsmen, property developers and home owners. By following a strategy focused on enhancing the professionals' competences, colour planning remains a lively process, but is henceforth based on a better comprehension of the manifold factors to be considered in careful colour decisions.

After defining these specific targets, genuine research methods and instruments had to be designed in order to adequately grasp the complexity of the urban colour space and provide reliable empiric data. Therefore, a comprehensive study was conducted considering six different points of view:

1. The general urban-planning view: a summary inventory of the colours and materials used for facade design considering every single building of the c
2. The focused view: detailed colour portraits of selected outstanding buildings
3. The tactile view: a sample collection of structures and materials used in surface design in architecture
4. The time-specific view: chromatic charts of period-typical colours used in architecture through the decades of the 20th century
5. The dynamic view: video renderings of urban interstices, of changing or mobile colour elements such as light, weather, seasons, advertising, traffic or people
6. The subjective view: a survey on the perception that Zurich's inhabitants have of the colours of their city

The lecture will give an introduction to the methods and instruments designed to carry on the research, followed by an insight into the manifold results and working tools compiled in the final stage of the project.

The project "Colour Atlas Zurich" was lead by Lino Sibillano and Stefanie Wettstein (Co-Directors Haus der Farbe), Jürg Rehsteiner (until 2009 Director of the Building Consulting office Zurich, now City Architect of Lucerne).

# Photoshop as a tool for museum lighting design using apriori colorant optical data

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## Abstract

Museum lighting design is a balance between preventative conservation, curatorial aesthetics, architectural constraints, and adhering to the artist's intent (when known). For works of art that are highly susceptible to damage from optical radiation, tungsten lighting best meets this balance. With the introduction of solid-state lighting and novel filters and lamp design for tungsten, there are more choices of correlated color temperature and spectral power distribution. Both impact a work's appearance and there are two approaches to evaluate this inter-relationship. One is to observe the work under the proposed lighting condition, sometimes not possible. The second approach is to image the work such that its spectral reflectance is obtained at a sufficient spatial resolution for visualization. Using colorimetry and a chromatic adaptation model (CAT), the work can be rendered for a given test light. Unfortunately, very few works of art have been imaged spectrally; most are either color managed or simply unassigned RGB. If we make assumptions about likely pigments used by the artist, it is possible to estimate a work's spectral properties, enabling lighting comparisons using color-appearance models. Because these computations require non-linear optimization, such analyses are impractical, especially for lighting designers.

The approach used in this research was to use the computational tools that are contained within Photoshop's color management "color engine." The first step was to build an optical database of artist materials to enable determining the relationship between a set of colorants and their spectral color gamut. Next, at least three chromatic paints plus white were selected representing the work's palette. Using optimization, a multi-dimensional look-up table (MLUT) was created relating CIELAB and concentration. A second MLUT was produced relating concentration and CIELAB for any illuminant and observer of choice (including a CAT). The two MLUTS were concatenated and used to produce an ICC abstract profile (LAB to LAB).

An acrylic-dispersion paint palette was defined containing cadmium yellow medium, phthalocyanine green (blue shade), cobalt blue, quinacridone magenta, and titanium white. An abstract painting was created with these paints and imaged spectrally. Comparisons between the painting's measured color under illuminant A and its prediction using the profile verified the effectiveness of this approach.

Such profiles, particularly when created for specific palettes (e.g., old master, impressionism, etc.) can be used as a tool for museum lighting design.

# Optimal wavelengths of colour laser scanners

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## Objectives

Laser scanners pose a colorimetric challenge for the digitisation of reflective materials because they sample the spectrum at single wavelengths. A colour scanner with red, green and blue lasers generates an RGB triplet at each pixel position that depends only on the wavelength of each laser and the surface reflectance at those three specific wavelengths. The question arises as to which three wavelengths would be optimal for trichromatic laser imaging of objects with typical colorants?

## Method

Three independent sets of reflectance spectra from physical paint samples were used:
1. National Gallery London pigment set – 64 patches, measured at 2 nm intervals;
2. Berns-Taplin RIT pigment set – 100 patches, measured at 10 nm intervals;
3. GretagMacbeth DC Chart – 170 patches (no gloss), measured at 10 nm intervals.

Each dataset was interpolated to 5 nm wavelength intervals over the range 380-730 nm. They were combined into a single large dataset containing 334 spectra. Tristimulus values *X,Y,Z* were calculated for each sample under D65 and multi-laser illumination, using the Judd-Vos (1978) modification of the CIE 2-degree standard observer. These were converted to CIELAB values using the respective spectra of D65 and equal unit power of the lasers as reference white, and the colour difference $\Delta E^*_{ab}$ was calculated. Median and mean values were calculated over all the samples. By exhaustive search, the combination of three laser wavelengths at 5 nm intervals was found that minimised the mean colour difference between D65 and laser illumination over the full pigment set. The search space was limited to all combinations of laser wavelengths, at 5 nm intervals, in the three ranges: blue 380-495 nm; green 500-570 nm; and red 575-730 nm.

## Results

The three curves in the figure represent one-dimensional sections through the three-dimensional distribution of mean and median $\Delta E^*_{ab}$ values for the combined dataset. The global minimum point was sharply defined with respect to all three variable laser wavelengths, giving optimal wavelengths of 460, 535, 600 nm. These lie close to the peaks of the second and third orthonormal vectors of the colour matching functions (i.e. the colour opponent channels) and correspond to Thornton's prime wavelengths of vision.
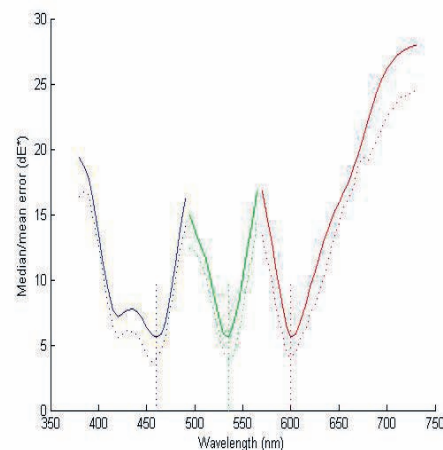
# Text segmentation in natural images robust to photometric effects

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## Abstract

One of the most challenging tasks for any computer vision system is to recognize the changes in an image which are due to a change in the underlying imaged surfaces from changes which are due to the effects of the scene illumination. The interactions between lights and surfaces are complex and introduce unwanted artifacts into an image. For example, shading, shadows, specularities and inter-reflections, as well as change to local variation in the intensity of color of the illumination all make it more difficult to achieve basic visual tasks such as text extraction or background extraction. In order to attenuate these effects illuminant-invariant models have been proposed. Several studies have shown that these models greatly attenuate most of effects described above. In this paper, we show that these models suffer from limitations and do not perform well when addressing complex illumination conditions.

In this paper, we propose a novel method for detecting and segmenting text layers in complex images. This method is robust against degradations such as shadows, non-uniform illumination, low-contrast, large signal-dependent noise, smear and strain. The proposed method first uses a geodesic transform based on a morphological reconstruction technique to remove dark/light structures connected to the borders of the image and to emphasize on objects in center of the image. Next uses a method based on difference of gamma functions approximated by the Generalized Extreme Value Distribution (GEVD) to find a correct threshold for binarization. The main function of this GEVD is to find the optimum threshold value for image binarization relatively to a significance level. The significance levels are defined in function of the background complexity. This method is much simpler than other methods for text binarization and produces better text extraction results on degraded documents and natural scene images.

From the results we obtained from ICDAR (2003) and DIBCO (2009) benchmark datasets we can conclude that the binarization algorithm proposed in this paper performs well on images with shadows, non-uniform illumination, low-contrast, large signal-dependent noise, smear and strain. In comparison to other methods mentioned in DIBCO (2009) the proposed method is much simpler. The experimental results that we have obtained show that the proposed method enables to face problems due to the effects of the scene illumination to greater extent.

# Color naming experiment using 2D and 3D rendered samples

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## Abstract

In the recent study of image science and technology, color names are the focus of the attention, because the language is intuitively easy for us to represent color information, compared with numerical representation such as the tristimulus values and the RGB values. In our previous study, we collected recall color terms for modern Japanese over several decade years. Then we found out that a set of 15 color terms, including gold, silver, aqua, and yellow-green in addition to the Berlin and Kay's 11 basic color terms, is constructed stably as important color terms in Japanese daily life. This paper describes a color naming experiment using the 15 basic color terms in Japanese. We investigate correlation between color terms and color coordinates in a color space based on psychophysical experiments. In conventional color naming experiments using a 2D clue such as color patches. However, in the real-world scenes, most objects have 3D shapes which can generate illumination effects such as glosses, highlights and shadows on the object surfaces. In our experiments, we use both 2D and 3D rendering samples as a clue, and analyze the relationship between color terms and object surfaces.

We first develop a color term collection system which can produce 218 test colors at grid points within the monitor's color gamut in CIELAB color space. For each test color, we generate the following three rendered sample sets: (1) 2D circle patch painted by a uniform color, (2) 3D sphere with shading effect by diffuse reflection component and (3) 3D sphere with all illumination effects of shading and specular by both diffuse and specular reflection components. The 3D sample sets in (2) and (3) are rendered by the Phong reflection model. The illuminant is assumed to be D65.

Experiments conducted for five normal subjects in the darkroom. In each sample set, 218 color samples were displayed at random. The sizes of those color samples had a diameter of 145 mm, and the distance between the monitor and a subject were about 700 mm. The subjects answered appropriate color name to each of the displayed color samples from the 15 terms. Our system recorded the color name and response time.

Experimental results show that the partitions among color terms definitely change between 2D and 3D samples. The numbers of such color names as black, red, blue, brown, gray, purple, and gold increase for the 3D sample sets, compared for the 2D samples. On the other hand, the numbers of pink, orange, yellow-green, and aqua decrease. The fomer color samples are darker than the latter color samples. In other words, the numbers of bright color names for the 3D samples decrease. The average of response time for 3D sample sets is significantly faster than 2D color samples. Human being perceives object color on 3D surface rather than 2D surface. The above results suggest that color naming to object surface can be specified stably not only by the matte surface color but also by the illumination effects of shadows and highlight.

# Validating large-scale lexical color resources

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## Abstract

The use of the Web for crowd-sourcing lexical color resources has succeeded in creating databases consisting of millions of color terms. Various researchers have demonstrated the value of this data, but questions related to the quality and reliability of the data remain, because each large survey is tainted by a small number of disruptive subjects. The challenge is to cull the resource by identifying and eliminating the data contributed by these disruptive subjects.

With a million color terms, it is no longer possible to individually inspect color terms and we need an automated process. Machine evaluation through natural language processing is possible, but this introduces the added complexity of pre-defining properties and criteria for data validity, which could improperly cloud the data.

Color terms are terms associated with colors. Instead of examining the terms, we can examine their colors. Our visual system can process purely visual information at a much higher bandwidth, because the language system and its complex cognitive processes can be bypassed.

In this contribution we propose a graphical approach in which the associated colors of large-scale lexical resources are first machine-sorted by color appearance so that human experts can efficiently identify outliers or questionable entries by simply looking at a graphical rendering. A recent test with the R. Munroe and E. Ellis Color Survey Data has allowed us to process over a million color terms.

The methodology is as follows. First, the color terms are binned categorically, where each bin corresponds to a monolexemic color term. Second, for each term the associated red, green and blue sRGB values are further quantized and then these device values are sorted in lexicographical order. Third, the sorted device values are displayed as raster images in which each term is represented by a pixel drawn in the associated color. Finally, observers identify visually the outliers for each color term by inspecting the raster image.

Using this procedure, the relatively rare disruptive subjects are efficiently identified and tagged. This process can be extended to multiple experts and a weight can be derived for the entries in the lexical resource. Experiments show that even using such crude appearance attributes as the sRGB values, the methodology is very effective and it is not crucial to use more sophisticated representations, such as for example correlates of hue, lightness and chroma.

Based on this methodology, we show that the Munroe and Ellis Color Survey Data correlates well with data obtained in a controlled laboratory experiment. This is a surprising result given the informal nature of this resource. It is also a testimony of the validity of crowd-sourcing for scientific experimentation.

# Color interaction as apparent luminosity in painting:
# How this is created and a history of its use in painting

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## Abstract

The presumption in this presentation is that color is used systematically in painting so that all colors affect each other in order to give rise to certain perceptual effects. The specific perceptual effect focused on in this paper is that of "apparent luminosity", that is to say, the experience by a viewer of a sense of luminosity from a painted surface which is physically only reflecting light of various quantities and in various wavelength compositions.

In order to understand how apparent luminosity may be accomplished in painting one must first review the explanations and definitions by 19th century and later gestalt psychologists culminating in the work of David Katz who offered the idea that color is presented in differing "modes of appearance" including: "surface mode", "film mode", and "luminous mode". Other factors furthering the discussion will be: 1)the definitions of "figure and ground" and "apparent transparency"; 2) variation of focus and, a factor closely tied to focus, the near assimilation of colors; 3) color constancy and the phenomena of simultaneous contrast and afterimages or successive contrast.

A history of the appearance of this effect in the evolution of representational painting will be traced from the Renaissance to the early 20th century. This begins with the attempts to model color in light and shade by Massacio, Piero and their contemporaries and the instructions written by Cennino and Alberti to make a representational scene and then moving to the later developments offered by Leonardo. Progressing over the centuries other developments in creating a sense of luminosity are seen in the highly contrasted work of Caravaggio; the Dutch 17th Century School including Vermeer; and also the evolution of "in situ" work and especially Baroque ceiling paintings later perfected in the work of Tiepolo. New issues will be shown to arise from Turner's approach and later the American Luminists and the Impressionists and Neo-Impressionists.

In the early 20th century artists developed new experiences of luminosity by adopting these same techniques to produce apparent luminosity from the experience of the surface of the canvas without a representational intent: Russian Suprematists, especially Malevich and Kliun; Bauhaus era artists such as Moholy Nagy, Klee and Kandinsky; American artists of the post war era such as Albers, Rothko and Reinhardt; the Swiss concrete artists Bill and Lohse; later American artists such as Louis, Olitski, Anuszkiewicz, Stanczak, and Poons; and many others. This can be contrasted to other late 20th century and contemporary art which actually uses physical light as seen in the work of Flavin, Cruz-Diaz and others.

Recently more complicated issues are suggested by immersion art - attempts to present to the viewer a total surround of color.

# Interaction of mosaic pieces

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## Abstract

The subject of this paper is the interaction of color and light in the material *mosaic*. In addition, it discusses the viewer as a "participant" in the room adorned with mosaic. The paper deals with mosaic used as a building material and ornamentation. The theory and technique of its artistic scenes and geometrical patterns are traced in ancient and contemporary architecture.

The Byzantine technique with walls done with mosaics was new in the 5th and 6th centuries. In Ravenna, in the basilicas, the Byzantine mosaic masters worked with entire walls of mosaic made up of small pieces of colored glass and gold, affixed to mortar. Thus, the mosaic masters possessed knowledge of the eye's ability to apprehend color mixing. They also acquired understanding of the changes colors underwent with distance, and also of the interaction of light and material.

When viewing a mosaic wall, the changes of the material from matte to shiny can be discerned: how the mosaic is reflected depends on its angle against the wall – placing two colors of the same basic hue but with different tilt angles such that each ends up with its own hue. The effect results from light projecting and reflecting different information to the eye. Reflection is also dependent on how the light strikes the mosaic pieces, on whether the tesserae are glass (blank) or marble (often matte), on the viewing angle, and on how the viewer moves in the room.

The appearance of the rooms varies in the basilicas, but no movement of the subjects on the walls is perceived. The color hues are perceived as stable and unchangeable, and unaffected by nearby colors. But with the movement of the viewer in the room, and the changes in the eye's view, the mosaic walls are transformed from matte to shiny and back again. Through the mosaic, the viewer participates in the process of change.

This paper is also mirroring some examples of modern mosaic pictures and patterns. One example is the Stockholm City Hall (1923) with its Golden Hall created in mosaic by the artist Einar Forseth. The walls of the Golden Hall are covered with more than 18 million glass and gold mosaic pieces in a Byzantine inspired style. Another example is an underground station situated in Rinkeby, a suburb of Stockholm, created by the Swedish artist Nisse Zetterberg in 1975. Zetterberg used mosaic in gold, in the tesseare technique and with different angels from the background. A third – perhaps more dubious – example is a dwelling-house near Vasaparken in central Stockholm. The house owner ordered a mosaic exterior wall, made fast to a minimal cost. Computerized technique nowadays makes it possible to fabricate the tesserae/mosaic pieces as standardized components. Is this a way to maintain the mosaic tradition?

# The enigma of the offing: The representation of light and colour in sea and sky

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## Abstract

For artists involved with landscape, a fundamental investigative and aesthetic concern is the relationship between the forms, spaces and colours seen above and below the horizon. For image makers in particular this horizontal division is often used as a powerful compositional construct, emphasising the separation of land and sky, or sea and sky. This paper explains a concentrated study of the visual phenomena seen by looking across sea water, and particularly the division between this water and the sky immediately above it; a place described poetically as the area of the offing, or factually as the sea level horizon. The fundamental objective of this study is to understand something of the nature of the colours seen in these phenomena and how in turn these colours can be used pictorially to evoke such encounters.

While the act of looking across water has been the stimulus for many painted images made by the author over a number of decades, the need to be as authentic as possible to this experience has lead to a method of painting that emphasises explicit temporal engagement with the subject. Images are not made at a remove from the study area from photographic references but from the process of direct on-site representation of the immediate and transient environment. The constant variations of atmosphere and levels of illumination inherent in all maritime locations, and certainly in those observed throughout this study, has been the stimulus to a process of creating serial imagery where the same view has been represented many times, each with either dramatic or subtly different colour harmonies. The amalgam of many images presented together being seen as more representative of the subject than a singular or isolated picture.

This study has revealed that colour is indeed context, that the colours above and below the horizon in these spaces are in constant and dynamic association and change. The complexities of the physical forces involved in sea and sky make the reasons for their apparent colour variability difficult to unravel. Perhaps the best that can be hoped for is to understand the colour relationships that make up their totality; for these colours do define the character of the separation of sea and sky, the variables of light intensity, the changes within the atmosphere, and the human experience of observing all of this.

# Interactive chromatic tools for architectural colour design

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## Abstract

Architecture is the interplay of volumes constructed with material surfaces and details. Light and shadow reveal their colour, texture and form in space and time. While colour has the ability to manipulate form, reconstruct space, and influence our movement and our appreciation of space, colour is most often neglected in modern architectural projects. Colour is added as an afterthought or as a last minute decision. Lighting designs and material palettes often suffer with budget cuts at the end of a building's programme. Architectural education and practise lacks fluent expression of architectural ideas through colour and light. Form, surface, colour, texture and light are not integrally considered. These mediums are not valued as a technical or aesthetic means of producing architecture.

However, colour specialists from different parts of the world have created tools to support designers develop their individual ways of seeing and their vocabularly and language to construct ideas through colour, material, light, texture and volume. Tools which engage observation and engender fluency of expression in establishing relationships between planes and volumes in artificial and natural light. Today, the design world is bombarded with mass produced colour charts in printing inks. The market dominance of international colour matching systems such as Pantone and RAL have led to a banal standardisation of colour choices for all types of architectural materials. It is therefore important to reflect on the way that we see colour and use it.

This paper will address a number of colour tools which are each in there own way interactive, encouraging the interplay of light and colour in three dimensional space and endeavouring to give voice to intelligent constructions of colour material surfaces in light. Colour tools designed by Le Corbusier, France and Michel Cler, Aalto Colour and Pierre Bonnefille to support designers to create colour harmonies appropriate to architectural space. Colour tools aiming to improve syntax and grammar in our design world. The use of colour and material as a fluent language to manipulate the perception of plane, form and space in architecture can only but enrichen and improve our built environment. The complex boundaries caused by fluctuations of light, shade and hue in architectural spaces are often the moments of poetry and emotion that we remember.

# Spatial visibility: Camouflaging functions of recommended colour design solutions for improved accessibility

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## Abstract

Current Swedish recommendations about contrast marking of architectural details in public spaces, intended to improve accessibility for people with reduced sight, may function as camouflage in relation to the room as a whole. The recommendations are based primarily on research in two dimensions and figure/ground relations. The recommended contrast marking of potentially dangerous objects or elements, functional zones, room edges and guide paths seems to dominate over more subtle variations – pattern of shadows given by the light situation – which define the volume shape of a room. The suggested solutions may be efficient in making hindrances and paths to predetermined goals visible, but it is doubtful if they help the visually impaired person to perceive and autonomously orientate in the room. While offering visual handrails they may even enhance the visually impaired user's handicap, making him/her more dependent on the recommended contrast marking.

Concepts developed from camouflage theory are used in a *Colour-Shape-Interaction Analysis* to identify how recommended solutions affect spatial visibility and how visibility of volume shape could be enhanced by instead using co-shading. Three types of solutions are studied: marking of room edges, of pathways and of stairs. The colour design effects are analysed and experimentally manipulated in photographic representations to allow visual comparing between recommended, 'neutral' and co-shaded colour design solutions.

This paper presents descriptions of how both recommended colour design solutions and co-shading affects the visibility of shape in the three studied type of cases. It shows that the recommended contrast marking of edges and details tend to dominate over the finer pattern of shadows that reveals the real shape, by either counter-shading or disruption. It also demonstrates how these developed camouflage concepts, not previously applied within this area, can contribute to more relevant descriptions, analysis and understanding of how colour design affects the visibility of a room. The main conclusion is that recommended contrast marking solutions function as camouflage in relation to the volume shape, while co-shading instead enhances the visibility of volume shape.

# Montpellier the white city, Toulouse the pink city, two territories in color and light, two identities in question

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## Abstract

**Montpellier and Toulouse**, two cities in the South of France, two millennium cities: the first one, Mediterranean and sunny; the second one, authentic and landbased. Renowned cities molded by stories and history, their reputations precede them. Revered, dreamed, idealized, it is today complex to distinguish what recovers from **the History** and what recovers from the fantasy, **the image**.

Having traditions and the strong practices of color and light, they now have **tools to guide their color and light development for their architectural, urban and landscaped heritage** (Master plan Development Light, Light Squeme and Chromatic Charters). Their conceptions have been done by experts of the city, engineers, designers...

These cities having a regional as well as national aura, give themselves to look at, to discover not only through their particular stories, but also through **the creative and identity signatures**. Thus, what is in question is the identities of the city.

**Beyond its complex identitary stratifications, the material is there and preexists**. By its color, its texture, it **is one of the original heritages of the city**, one of the first data of its aesthetics and its history, which influences, characterizes it. This material necessity, conjugated to the history, supplies to **the creators and the city makers** the main themes of their abstract approach. But in fine, it returns to the inhabitant to perceive, in their **individual experiences of the city**, tense and visible red threads, and other invisible and thin threads which belong to them. From this meeting of the conceived and the lived of the city are born **signs and symbols** which govern its past, contemporary and future image.

The examples of Montpellier and Toulouse confirms that the **urban aesthetics** is a key issue which stakes exceed the only concern of **conservation of the heritage**. So the mediums of color and light are more and more exploited and adapted to protect the built heritage, but also to value it and make the city a place of exception. In Toulouse, a chromatic charter ordered by the city was realized for the historic center and transformed its appearance. In Montpellier, a light designer use his gaze for the city by staging it. Can the artists and designers thus, by their sole signature, add an "extra soul" to the city? Does **this showcase city**, which enjoys the reputation of a designer, become only the object of its creator, to the detriment of its own history? **Rightful renewal or pure image strategy**? What are the consequences of such practices from a heritage point of view but also from **the perspective of sustainable development**?

# Chromatic interactions of surfaces and illuminants: Physico-environmental regularities as cues for the perception of colours

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## Abstract

The visual stimulus associated with an object surface varies with the illumination falling on the object. To accomplish the constancy of perceived surface colours under changing illumination, the visual system must in some sense internalize the regularities of the chromatic interaction between observed surfaces and the incident light as these jointly determine the visual stimulus.

In this talk I will present a theoretical analysis of the chromatic interaction between surfaces and illuminants in our natural environment. This analysis yields four regularities inherent in the retinal chromatic shifts induced by changes of illumination:

1. A multiplicative change of the cone excitations under changes of illumination, where the excitations of each cone type are scaled for all surfaces by the same factor.
2. A chromaticity-dependent change in luminance: surfaces similar to the illuminant in chromaticity are rendered as lighter than surfaces dissimilar from the illuminant.
3. A resistance of narrow-band surfaces to chromaticity shifts.
4. A compression of the chromaticity gamut with narrow-band illuminants.

I will also summarize psychophysical experiments that address the question which of the above mentioned regularities are taken into account by the human visual system for perceiving surface and illumination colours. In order to obtain almost constant surface colour percepts under different illuminants, the visual system must estimate the chromatic properties of the current illumination. One class of cues to the illumination are the so called chromatic scene statistics: statistics of the chromatic distribution within the retinal image received from the scene. For instance, under a reddish illuminant the retinal image becomes on average reddish and thus a reddish mean chromaticity within the retinal image could indicate a reddish illuminant. However, taking the mean retinal chromaticity as a cue to the chromatic properties of the illuminant faces a difficulty: a non-neutral mean chromaticity cannot be attributed unambiguously to a chromatically biased illuminant because to some degree it also could be caused by a chromatically unbalanced composition of surfaces in the scene. To enhance the estimation of the illumination, it would be helpful to take additional scene statistics into account if they vary systematically with the illuminant. Candidates for such additional scene statistics as diagnostically useful cues to the chromatic properties of the illumination can be derived from the above mentioned analysis of regularities in the chromatic interaction between surfaces and illuminants. The psychophysical experiments presented in the third part of this talk investigate which of these candidate cues are indeed taken into account by the human visual system.

# A study on color difference based on visual assessment of existing lighting and LED lighting

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## Abstract

From September 2012, all types of incandescent lamps will not be available from stores any more, and the supply of lamps with low energy efficiency will be banned. Thus, demand for lamps with high energy efficiency is expected to increase progressively. In this context, LED lighting with low power consumption, diverse colors and ease-of-customizing has begun to be spotlighted as an alternative to promote energy-savings and environmental friendliness. To cope with such social trend, it is necessary to evaluate the LED lighting in terms of appropriateness of its indoor use. LED lamps show distinctive characteristics compared to existing light sources such as incandescent lamp or fluorescent lamps, as its design is quite different from the existing ones. If such difference caused by characteristic spectral energy distribution of LED lamps is large enough, it may cause repulsion to users of the light source owing to large difference of colors. Even more, such light source may not be applied in some operations.

Thus, visual assessment was made in this study to find out the color difference between LED light source and existing ones. The test was implemented as follows:

1) To perform the test, two light cabinets (610 x 510 x 550 mm) were built to compare a standard light source and LED lights concurrently. Inside walls were painted with N7.5 achromatic color of to eliminate influence of surrounding colors. 2) The subject of assessment had the diversified color arrangement patterns as facilitated in the color design field. 3) Emotional evaluation was implemented following the evaluative adjectives under the standard light source and LED lights. 4) The number of subjects who were selected among graduate students majoring in illumination and chromatics who might have good capacity in distinguishing colors.

The result of the visual assessment standard light source and LED lights was analyzed through the factual analysis, and the difference of the result was demonstrated through the fact float chart.

# Colour differences for a Farnsworth-Munsell 100-Hue test illuminated by a D65 source

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## Abstract

The Farnsworth-Munsell 100-Hue (hence FM-100) test is a well-known exploratory tool for the examination of human colour vision. Our current goal is to analyze the distribution of the 85 samples of this test in different colour spaces, with a particular focus on colour-differences between samples. From a completely new issue of the FM-100 test, we performed 3 independent spectroradiometric measurements of each one of its 85 samples, placed on the floor of a GretagMacbeth Spectralight III colour cabinet with a D65 source. The optical axis of our PR-704 spectroradiometer was tilted 30º with respect to the normal to the samples. The CIE 1931 colorimetric observer was assumed. Our main conclusions can be summarized as follows:

1. The 85 samples have almost constant lightness (coefficient of variation of $L^*$=3.2%), but high chroma variation (coefficient of variation of $C_{ab}^*$=23.7%), in such a way that the samples are not placed on a circle neither in CIELAB or CIECAM02.

2. On the average, contiguous samples showed CIELAB lightness-, chroma- and hue-differences of 20.4%, 20.1% and 59.5%, respectively. Surprisingly, the CIELAB hue-differences are not the main ones for some colour pairs.

3. Colour differences between contiguous samples are not constant, and, for the whole set of 84 colour pairs, the coefficients of variation were 33.9% and 33.5% for the CIEDE2000 and CAM02-SCD colour-difference formulas, respectively.

4. Some pairs of samples showed anomalous colour differences: $\Delta E(27,29)<\Delta E(27,28)$; $\Delta E(35,33)<\Delta E(35,34)$; $\Delta E(47,49)<\Delta E(47,48)$; and $\Delta E(49,47)<\Delta E(49,48)$, where $\Delta E$ designates both the CIEDE2000 and CAM02-SCD color-difference formulas.

5. Although the reference illuminant for the FM-100 test is C, using illuminant D65 (or the D65 source of our current colour cabinet) can also be admitted. Thus, on the average, the colour differences between contiguous samples changed less than 0.1 CIELAB units when illuminant C is replaced by D65.

In summary, although current results must be tested from other issues of the FM-100 test, probably it will be convenient to improve the set of samples provided by the FM-100 test, looking for an improved uniformity in modern colour spaces. The theoretical appearance of the samples of the FM-100 test for young/aged people is also another aspect we are currently investigating.

# The impact of luminance level on the assessments of colour appearance and difference

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## Abstract

Luminance is one of the major parametric factors in the viewing field. The objectives of this project were to model the visual effect, to evaluate the measured and perceived colour difference and to investigate the performance of various colour difference formulae and colour appearance models under different luminance levels.

Twenty observers participated in a unique experimental setup including two viewing cabinets and a combined psychophysical method using short-term memory matching and grey scale methods for the investigation. Five luminance levels (about 1258, 445, 33, 3 and 0.8 cd/m$^2$) were adjusted by using optical density filters in order to range from mesopic to photopic vision. Forty coloured textile hue difference pairs with a mean $\Delta E_{ab}^*$ of 7.8 and a textile grey scale were measured with a spectrophotometer and with a tele-spectroradiometer under all luminance levels. Statistical methods for colour difference distributions were used to check repeatability and stability of measurements. Moreover, the statistical index STRESS was used for estimating percentage of error by correlation of two data sets.

The data analysis revealed good performance for the group of observers with inter- and intra-observer variability 28% and 30% respectively. Furthermore, perceived colour differences decrease by 3%, 21%, 31% and 40% from the brightest luminance level (1258 cd/m$^2$) against the darker levels. The modelling of this visual effect in CIELAB and CIEDE2000 colour difference formulae revealed a linear relationship. The analysis on performance of CIELAB and CIEDE2000 colour difference formulae plus CIECAM02 and CAM02-UCS colour appearance models exposed that each formula gave a more accurate prediction than the inter-observer variability. In addition, it was found that CIEDE2000 performed better but the other formulae and spaces gave similar performances when individual scaling factor was applied to each experimental phase. However, when applying only one scaling factor to the visual results from all luminance levels, CAM02-UCS and CIECAM02 performed distinctly better among all the formulae and spaces studied.

In conclusion, the comparison between all findings revealed that CAM02-UCS performs better under different luminance levels than other formulae because of its consideration of luminance variation with better adjusting coefficients.

# Classifying papers according to their light scatter properties

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## Abstract

Light scatter in paper plays an important role for predicting the color of printed halftones. Scattered light within the paper bulk causes the so-called optical dot gain (ODG) or Yule-Nielsen-effect. The detailed knowledge of light scatter within the printing substrate can improve the accuracy of printer models and reduce the number of required training colors to fit the model to the printing system.

In this work we measured and evaluated edge spread functions (ESF) for a set of 12 papers. The measurement setup consists of a microscope in which we inserted a razor blade that covers a part of the light path to project an edge-shaped illumination onto the sample. A lens system was utilized for focusing the razor blade's shadow onto the sample surface. Furthermore, we introduced a sample holder for accurate focusing. This holder allows the sample surface and a reference, in this case a first surface mirror, to be aligned in one plane that is parallel to the microscope stage. This enables us to adjust the focus using the first surface mirror and then simply slide the sample holder to the sample without leaving the focus. A novelty compared to other setups is that we can use the edge projected onto the reference as the edge that is "best to achieve" by the setup. This edge's sharpness is only limited by the modulation transfer function of the optics. All measurements are performed relative to this reference edge. The sample holder allows a rotation of the sample to analyze anisotropic scattering. Images are captured with a camera for each sample and the reference. We found that the assumption of isotropic scatter is valid for the papers examined here. Changes to our previous measurement setup are the use of a green LED as light source, a monochrome CCD camera for detection and polarizing filters to reduce the impact of surface reflections.

For one sample, we capture the edge projection in six angles with 30° distance, covering a total angle of 180°. All images are averaged to one single measurement. We performed a series of measurements on 12 papers: 4 inkjet photo papers and 8 fine art papers. From the measurement results, we can clearly distinguish three different paper classes, two for inkjet papers and one for fine art papers.

It seems to be reasonable that a general classification of papers due to their scatter properties is possible. The optical dot gain property of a paper could directly be deduced from its light scatter class. This could simplify modeling printing systems or fitting printer models to a given printer setup.

# Interference colors on titanium: From science to art

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## Abstract

*In memory of Pietro Pedeferri (1938–2008)*
The study of interference colors that may appear at the surface of a metallic material goes back to the early XIX century. At that time Leopoldo Nobili, an Italian scientist, first studied and obtained with an electrochemical technique colors on the surface of a lead plate in the presence of an acid solution. From that time on other studies followed, focusing on other metals and in particular on titanium. Among them the work of Pietro Pedeferri gave rise to the development of a robust technique that permits to obtain beautiful colors on the surface of titanium, while maintaining an engineering control of this powerful painting technique.

The formation of a transparent oxide film on titanium, with thickness ranging from a few nanometres to a few hundreds nanometres, generates the appearance of chromatic effects arising from the interference of light radiation illuminating the oxide.

Changing the surface appearance of titanium is not an issue, but a robust and precise control of the anodic or thermal oxidation is mandatory when brilliant and saturated colours are requested. The method proposed and patented by Pietro Pedeferri is a powerful technique that permits the obtaining of a wide range of beautiful colours.

The oxide thickening can be achieved by means of anodising. Both hue and saturation strictly depend on anodising parameters, in particular on cell potential. Hence, a deep understanding of anodic oxidation is essential to assure an optimal control of morphology, structure and homogeneity of the nanostructured layer, which determine its properties, from the aesthetic qualities to durability.

Furthermore Pietro Pedeferri used this electrochemical method as a painting technique exploiting a peculiarity of the oxides growth. In fact, although the final colour depends on the cell potential imposed in the initial stage, colours that appear at the metallic surface are also strongly influenced by the very first conditions of the electrochemical process. This behaviour, called "memory of titanium", permits the obtaining on the surfaces of pattern and images called "appearences" in honor of Nobili, the inventor of metallocromic art. These appearances show invisible aspects of phenomena that took place, or that are taking place, on the surface of titanium. Pietro Pedeferri called the former field appearances and the latter movement appearances.

Field and movement appearances are different, and therefore transmit different sensations. There is one thing they do equally as well, that is, to show the invisible side of nature.

# Measuring dynamic lighting atmospheres

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## Abstract

Solid state lights have in recent years revolutionized lighting. Their projected efficacy and cost, as well as the use of more environmentally friendly raw materials compared to traditional light sources and the main competitors, promote LEDs into a leading candidate for the light source of the future.

The revolution, however, is brought by the unique capabilities of LEDs like enabling full control of intensity and chromaticity as well as generating light effects with high spatial and temporal frequencies. This leverages lighting to a status of a new communication and artistic medium. Most natural light is dynamic and the changes happen without human interaction. Contrary to this, changes in traditional lighting systems are interaction driven. In this work we explore the possibilities of creation of dynamic light effects without direct human interaction.

The introduction of new capabilities also introduces new challenges. The freedom gained using solid state lighting systems increases the number of control dimensions resulting in increased control complexity. The perception of the atmosphere created by the lighting, however, is not uniquely determined by the individual lights and their settings. A model that can predict the perception of a space can be used both in the measurement of the perceived effect and the creation of a desired effect. Vogels (2008) has recently introduced the "atmosphere perception model" that captures the perceived atmosphere of a space using four dimensions: coziness; liveliness; tenseness; and detachment. An important distinction in the model is that it measures the affective evaluation of the space and not the affective state (mood) of the person in the space.

Previous atmosphere perception studies have been carried out using static atmospheres. The aim of the study presented in this work is to understand the influence of dynamic light on atmosphere perception. To explore this influence, a user study was designed and carried out. As a first step, the influence of five factors (speed, direction of change, amplitude of change, type of change and spatial distribution) on the perceived atmosphere was studied. Stimuli in the experiment were dynamic light variations, produced by wall-washers and led-spots on a single wall in a mock-up living room setup. Results from 39 participants show that nearly all the factors tested had a significant effect on the perceived atmosphere and the overall attractiveness of the room. These results can be used to create personalized dynamic atmospheres and design intuitive and effective lighting controls. In a subsequent interview 72% of the participants indicated that they want dynamic lighting in their living room. However, the quantitative findings show that smaller amplitudes of change as well as slower light effect were seen as more attractive, showing preference for subtle dynamics.

# From motion to emotion: The color-light event and the experience of the interval

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## Abstract

I will deal with the interaction of color and light in contemporary artistic practices both as a researcher and as an artist. Based on my own installations, I will reflect upon the relationship between color-light and the movement of perception in our sensorial experience of color. For various reasons, artists in all times have been interested in the power of color, whether it be the power of color in itself or as a reflection of light ; they have also been fascinated by its mobile and ephemeral dimension ; I will try and demonstrate how the contemporary manipulation of colored light prolongs this artistic tradition. In particular, I will deal with the question of monochromatic color and of the interaction of colors in painting as compared with the contemporary use of colored light. After a few examples of artists who use moving light, I will show how my own installations try to avoid both immobile and rapidly moving light in order to focus on interval-enhancing *slowness* as a factor of the emergence of color.

The first part, entitled « From pigment to light », will describe the specific breakthroughs of color-light as opposed to pigment, and will use the works of artists and art critics of the 1950s and 1960s, such as the Light and Space artists and Clement Greenberg.

Part two, « Allover, color field and Ganzfeld : towards a colored space », will then take into consideration the question of pictorial format with painters such as Pollock and Rothko painting ever larger canvases that engulf the beholder's total perceptual field.

Part three, « From fixed color to color variation », will be about light works that include temporal evolutions and rhythmic structures—such as Ann Veronica Janssens *Donut*, for example. It will be based on texts by Josef Albers, Bridget Riley, John Gage, and Edwin Herbert Land.

Part four, entitled « The flow and the interval ; or the experience of the advent of color » will allow me to present my theory and practice about the experience of color as interval. Based on texts by Rothko and Matisse and on a description of two recent installations of mine, this part will show how I use duration and slowness in order to provoke sensorial and emotional experiences in relation with the *color-light event*.

# The shadow of colors in Karagöz: Interaction of color and light in turkish shadow theatre

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## Abstract

*Karagöz* is a shadow play. Manipulated figures/*tasvirs* are projected behind an illuminated white screen. But, it is situated at the limits of shadow play due to its characteristic color scale. Thus, *Karagöz* figures consist of two-dimensional flat silhouettes that are made of brightly painted transparent camel hide projecting color into their shadow. Certainly, the concept of shadow and color depend on *light*. Even the curtain, the dream curtain – *hayal perdesi* –, the light that animates the puppets, and the puppeteer called *hayali* all represent the concrete. *Hayal* (dream) also means the puppet. The element of the light, equilibrates the traditional and eclectic language of form and color. The puppet *Karagöz* whose name is given to the play is the protagonist that represents the people. The other character is antagonist *Hacivat*. They reflect the multicultural panorama of Ottoman society and the heroes of the historical common cultures create a joyful and colorful world. A shadow puppeteer with a complete set of *Karagöz* puppets should own 400 figures for a corpus of 30 plays. But above all, *Karagöz* is an image, and therefore this system of images is performed as a scene. In fact, *Karagöz* derives from pictorial art. No tales of *Karagöz* exists without shadow theatre. No doubt, these plays are expressed in form and motion. Another important distinctive feature is the puppets' capacity for movement. In this study, the relationship between form and meaning will be investigated through the concept of light and color in the level of the minimal sign. *Karagöz* has an odd and exaggerated but stylized representation. This timeless profile of the play gained its current look during the 17th century. Pieces of transparent leather compose the whole which are articulated. These mechanical movements which are based on clowning also originate the motion comics. The active and cheerful character appears more communicative by the dominance of red. *Hacivat*, the antagonist character of *Karagöz* conveys his conservative personality with less capacity of movement and by the opposition of green. Black contours on the characters outline the brilliant colors inspired from the Court miniature painting. The commercial artists practicing folk art also synthesized the medieval color palette of the East and the West. Its authentic palette mentioned metaphorically as festival colors are stained glass colors which is not designed to be seen with the naked eye. White translucent *Karagöz* curtain absorbs the inherent colors and therefore it reduces gradation of shades. Consequently, perceived colors are situated in an elusive structure.

# Facilitating surface, colour and lighting choice

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## Abstract

Human perception of a materials characteristic may vary dependent on the illumination. Among the aspects that can suffer severely from the impact of lighting are colour perceptions. Light that falls on a surface is generally modified as it is reflected. What the human eye senses is an inseparable product that contains information about both the surface and the type of illumination used.

How the surroundings appear to us visually is an important factor in determining the expectations we have of an environment. All of the professionals involved in designing a space seek to control these expectations through, for example, spatial layout, selection of materials, choice of colours and the type of lighting. To a large degree the way the built environment unfolds in front of our eyes is down to architects, designers and engineers. Their choices determine how the environment will look alike.

Appearance science provides us with a whole catalogue of terms to describe optical properties like colour, texture, translucency and gloss. As separate entities, these are only of limited interest to architects and designers in their search for guides to assist them in envisioning the overall appearance of a space. We explored ways to facilitate the process of surface, colour and light choice from a designer's perspective. In one approach Kobayashi's cold/warm and hard/soft bipolar axes to quantifying designs were adapted to differentiate visual impressions. For the other approach material samples were mounted on a wall and have been lit differently. In this way the joint visual effect of material and light characteristics is easily observable.

The responses from designers and architects delivered us several insights on their needs concerning surface, colour and lighting choice. In conclusion can be said that designer generally can benefit from any method that succeeds to quantify appearance. As a specific strength we observed that a visual demonstrator is able to make even the most complex interactions immediately tangible.

# A model to link different modes and different aspects of appearance

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## Abstract

The model presented in this paper links different modes of appearance – illuminant, surface and volume – and different aspects of appearance – colour, texture, gloss, lustre and transparency. The model is a conceptual framework for a better appreciation of appearances. However, it must be recognised that no model can encompass the full complexity of common visual experience, of seeing the world in space and time. While much has been learned in 'laboratory conditions' with standardised lighting, uniform surfaces and isolated samples, this has been study of what is essentially an artificial world. In common visual experience, colour cannot be separated from other aspects of appearance, nor can it be insulated from context. And an essential contributor to how things are perceived is the light, its coherence, colour and intensity, and the way it varies from place to place and over time. In the first of two studies a collection of objects that exemplified different modes of appearance, and that exhibited a wide variety of appearance characteristics, was assembled as a 'still life' display. The room was lit by natural light from the windows and this was supplemented by a spot-light which was focussed on the display so that clear shadows were cast. The task for participants was to write down words for describing each object. The objects' variety, and the shortcomings of language, presented difficulties. Close observation and detailed descriptions were common. In the second study participants worked with sets of similar objects and were asked to 'arrange them in order'. It was difficult to arrange the objects in single linear sequences; some objects were the starting point for more than one sequence. The study revealed the importance of making a clear distinction between physical properties and visual phenomena and also that perception of visual phenomena depends on contrasts such as that between neighbouring colours and between highlights and shadows. From these studies came the idea of a three-dimensional network of appearance sequences linked through 'primary sensation nodes'. These are the reference points for the model presented here which has, at its core, a model proposed by Jose Caivano. Caivano's primary sensations are translucent white, transparent clear, opaque white, mirror (metallic) reflection, and the black of total absorption. To these are added full gloss white, rough textured white, and the glare of intense white light. Sequences of appearance phenomena, such as degrees of gloss, can be represented on lines which connect the primary sensation nodes. The lines that connect to black can also serve as the central achromatic axes of order systems for colours that are opaque, transparent, translucent and metallic, thus connecting colour to other aspects of appearance. Self-luminous colours relate, in a similar way, to the lines that connect to white glare. The model also links to modes of appearance: perceptions of luminosity to the illuminant mode, perceptions of transparency and translucency to the volume mode, perceptions of opacity, texture, gloss and lustre to the surface mode.

# Light and colour in the classroom – demonstrations from physics to the interaction of colours

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## Abstract

Computer graphics is an excellent tool to create illustrations, but exactly because of the ease of creating nearly any effect it may not be very convincing when we try to illustrate the separation, mixing or interaction of colours. While the material at the courses of the SENAI/CETIQT Colour Institute is presented in numerous Power Point slides, in our classroom demonstrations we illustrate the various concepts by showing real examples.

Projection of a spectrum: a spectrum may be projected by using a slide projector, an overhead projector or a video projector casting the image of a slit onto an optical grating (preferred to a prism in this experiment). Using coloured filters we can project blue, green red, cyan, magenta and yellow light onto the grating and show the composition of the additive and the subtractive primary colours.

Selective absorption: to show the interaction of light and matter we use an aquarium filled with water, and project the image of five coloured circles from the side: white, blue, green, yellow and red.

Specular and diffuse reflection: in a completely darkened room a mirror (for specular), a glossy white tile (for mixed) and a Spectralon tile (for diffuse) are placed in the bottom of an empty aquarium. The aquarium is filled with white smoke (we've been using dry ice) and the white surfaces illuminated with a strong red laser beam. From the side both the illuminating beam and the reflected beam or beams are visible in the smoke.

Partitive mixing (spectrum colours, complementary colours): this is an interesting demonstration with the Maxwell /Newton disk.

Interaction of colours: in his incredible book Albers explains in details the demonstrations. In this case some very clever computer simulations may also work very well. The White illusion is an example for which, together with many others, good computer simulation can be found, but in the classroom we are doing exercises with paper cuts which are even more effective.

Coloured shadows: this is one of the most dramatic classroom demonstrations, and maybe one of the most misunderstood. White light from one projector is mixed with coloured light from another in such a way that the lights form two overlapping circles on the screen. If we now place an object in front of the screen it will cast two shadows, one the colour of the projected colour light (e.g. magenta) and the other its complementary colour (in this case green). The demonstration may be done using two – or even three – coloured lights (instead of one coloured and white light), but, although even more spectacular, we find it somewhat confusing and thus less convincing then the simpler version.

# Management and development of proyectacolor.cl, a platform with theoretical and practical color resources in spanish, useful for the observation, education, discussion and aplication of color in visual communication design

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## Abstract

Proyectacolor is an academic project that was conceived in March 2008, as a response to a personal motivation. In those days, there were chatting, surveys and researching, leaded by myself, that diagnosed that most of Chilean graphic designers and Chilean graphic design students have a poor and strictly theoretical colour training, therefore they underestimate the real importance of applying colour carefully, and then, they use colour as decoration based on instinct. A change was needed.

With this assessment, the project started, and in its first stage of development, the most reliable scientific, artistic and academic colour sources were consulted: documents and books written by Newton, Goethe, Kandinsky, Itten, Gage, Albers, Birren, Kueppers, Munsell, Arnheim and Heller. Just to name a few.

Later, in the second stage of development, a four basic units content structure was generated: Colour Theory, Colour Perception, Colour Meanings and Colour application. All these units were aimed for the levelling on practical colour basics for Chilean graphic design students and, furthermore, Chilean graphic designers, even visual artists.

The next stage was to adapt these four basic units content to the new media format. I mean to put in digital, interactive and dynamic format some didactic material from hundred years of colour circles and patterns that have supported the study and explanation of this science, which have been provided by artists, scientists, chemists, and many others throughout history.

Once the four basic content units where complete, every single one with its didactic material on new media format, a sharing platform was needed. Then Proyectacolor acquired its final shape, including three different learning environments: it was configured as a triad: Website, Colour Course or Workshop and Blended Learning Objects.

This triad is based on the theory, very close to his bibliography, but also seeks the knowledge of color from the practical management of its interactive nature and techniques, like experimentation and comparison. The project ensures the acquisition of some basic color skills and their application, when the triad's three learning environments are operated in an simultaneous way.

Today, Proyectacolor is consolidated as a reference compendium of reliable practical and theoretical color resources, in the Chilean and Latin American context. This affirmation is based in the dissemination of the project through the Graphic Design and Visual Arts community, due to the implementation of the different social networks, which had made possible the interchange of impressions, experiences and comments.

# A comparative study on colour & light visualization techniques: architectural models versus full-scale setups

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## Abstract

Colour is used in interior design for different purposes since it is a flexible and powerful design element that serves as a tool of communication between people and the built environment. The primary aspect for designers to consider for interior colour design is to start with understanding the fundamentals, and from there, to find the ultimate colour solutions for specific design situations. Throughout the design process, designers should consider both the psychological properties of colour and the effects of colour on spatial dimensions. In colour design process, various colour visualization techniques are being used by designers. These techniques comprise a wide range of media/tools such as colour chips, coloured drawings, 3D models at different scales, computer aided simulations etc.

The results of many studies can provide cues to enhance colour design of interiors, however, architectural space is a more complex context considering its 3-dimensional effects on appearance and perception of colours. Hence, it was hypothesized that, colour/colour design evaluations of a space by 'subjects' who are shown different abstract media/architectural models would be different than the 'occupants' who experiencing full-scale setups. Accordingly, this study was conducted to explore spatial colour design evaluations of a full-scale experiment room representing a working environment, where 30 participants evaluated different colour schemes applied on surfaces under two different illumination levels (500 lux and 160 lux on the working surface), via semantic ratings. The findings were compared to the previous research by the authors. The results showed that the previously found differences between abstract and contextualized media are increasing when abstract media is compared to full-scale setups. The significant differences are generally observed for descriptive adjectives between evaluations of the abstract media/3D models and the full-scale setups for both illumination levels, while similarities are observed for evaluative adjectives. Harmony and pleasure set apart under different illuminations of full-scale setups. However, the findings related with the colour attributes (hue, chroma, value) correspondent with; hue and chroma appear more determinative over the adjectives related with pleasantness and arousal, while value appears determinative over spaciousness. The findings of research also supported that hue and chroma are more effective on evaluating spatial quality. The study concluded that abstract media may be used for initial color design decisions, however these decisions have to be reconsidered by using 3 dimensional, contextual media. Full scale set-ups have more complex relations in terms of color attributes, however these set-ups are found artificial by the subjects compared to the real life environments.

# Aspects of light: Colour, light and space/form/time

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## Abstract

In this practice-based research, architectural colour-as-light is explored as a means of renewing our understanding of the cycles of light which inhabit our buildings and imbue space/form/time with elemental meaning. Direct observation reveals aspects of light which are largely invisible to our eye/mind when the light is 'white'. 'Colour as light' offers an alternative to the ubiquitous neutrality of modernism and reconnects us to the interplay of space/form [1] and time that architecture can represent.

In the 21st century, urban dwellers live in a world in which the natural cycles of day and night have lost ground from their former primary place as intrinsically understood regulators of the fundamental rhythms of our lives. I suggest that architecture as a time-based, light-driven medium is an under-developed concept.

The works shown here represent a slowly developing research practice which has explored architectural 'aperture' as a source of directed light, and colour as a phenomenon which has the powerful capacity to reveal light's movement, in space and across form, through time. If the conventional understanding of window or door is replaced by the notion of '*aperture',* then 'function' may shift from 'viewing' or 'ventilation', 'access/egress' to 'opening for light'. This paradigm shift allows the understanding of light as a critical 'space-creating' element to regain important stature in the design arena: without light and its absence, darkness, there is no perception of form/space[2]. Each building site is in a *unique* relationship to the sun, and therefore has unique opportunities for constructing a relationship to light.

In the architectural artworks represented here, the light is coloured - and the works showcase not only the daily and annual cycles of sun angle and sun movement through space/time, but also the dynamic quality of light - the 'breathing' of light which flares, diminishes and fluctuates with infinite variation, and which moves across surfaces, highlighting their textural properties, and their reflective properties as well.

The work challenges the 'aesthetic of whiteness' that prevails as a modernist legacy[3] and points to possible new directions incorporating ephemeral and temporal colour as a potent element of space/form/time: architecture. Colour can reveal light's role as a potent carrier of perceptual and conceptual clarity, as it helps us see the fluctuating, unpredictable nature of natural light, and showcases natural light as a 'living', 'breathing' 'vital' element of our built environment. Coloured light is a source of deeply satisfying sensual experience that should be explored further in natural light manifestations, as lessons learned are of value for both natural and artificial light inovations in the built environment.[4]

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1   Giedion, S., Architecturee and the Phenomena of Transition, Harvard University Press; 1st edition, edition (June 1971)
2   Ando, Tadao,w/ Pare, Richard, photographer, The Colours of Light Phaidon Press, London, 2010
3   Batchelor, David, Chromophobia, Reaktion Books, London 2000
4   Porter, Tom, Colour for Architecture Today, Taylor and Francis Ltd., London 2010

# The impact of viewing illumination on perceived quality of fine art reproductions

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## Abstract

Art reproductions are viewed under various lighting conditions, from light booth to office to museum shop to living room to gallery. It is important, consequently, to understand and quantify the significance of the effect of changes in lighting. To explore this question, an experiment, supported by the Andrew W. Mellon Foundation, was conducted using printed reproductions of two oil paintings, a paint patch target, and a historic photograph. The originals were imaged by three major fine art institutions. Prints from the digital files delivered by each institution were generated on a Heidelberg Speedmaster following ISO 12467 and on an HP Indigo 5500®. With print sets made on offset and digital presses for each of three institutions as well as visually adjusted prints made for two institutions, eight reproductions were made for each piece of artwork.

Using the print reproductions, psychophysical experiments were conducted to generate relative visual ratings of image quality. The experiments followed a rank order procedure in which the observers were asked to rate the reproductions from the worst to the best representations of the original piece of art. Sixteen observers participated in the experiment. The experiment was conducted under two lighting conditions: D50 and the 'Horizon' lighting setting of a Macbeth light booth. A D50 light booth was used because this is the standard lighting condition in the graphic arts workflows used in printing production. The Horizon lighting condition was chosen because its warm light (similar to Illuminant A) is more representative of that typically used in galleries.

The results of the psychophysical experimentation indicate that, the lighting conditions had a significant impact on the relative rankings for the individual pieces of artwork, especially the historic photograph. For this image, the best renditions under Horizon lighting were the worst under D50 lighting. All of the renditions ranked statistically significantly different under the two lighting conditions. This suggests that prints made to match under one lighting specification may look 'just wrong' under another condition. It is an important point to understand when considering where prints will be evaluated and what viewing illuminant to specify in the print workflow.

The observers were also questioned regarding the acceptability of the print reproductions. Far fewer print renditions were found to be acceptable under the Horizon lighting conditions. This result makes sense given that the print files were created under the assumption that the prints would be evaluated under D50 lighting conditions. This is another important result of this testing; prints viewed under lighting conditions other than that specified in the print workflow are more frequently considered unacceptable reproductions of the original.

# Effect of observers' property on KANSEI impression of blackness in artistic digital Images

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## Abstract

*Kansei* is a Japanese word meaning a 'mental sense of subjectivity' in English, being a higher order function of the human brain. This cognitive function is taking part to all cognitive processes in which subjectivity is involved. For example, abstractive paint by Paul Klee would give strong impression to some observers, while it is nothing more than a color pallet to other people. We say the former observers have high sensitivity of *Kansei* in color and painted arts, while the latter observers have lower sensitivity of *Kansei*. Generally, it is independent of an observer's level of intelligence.

In this study, we investigated the effect of observer's property on *Kansei* impression of blackness in artistic images by comparing the results of two observer groups, students in the Department of Engineering, and students in Art Course. In the first experiment, we investigated the relation between blackness perception and the RGB values of color images of lacquer ornaments, secondly we explored how the blackness of black area contribute to *Kansei* impression of those images using Semantic Differential method. Finally, in the third experiment, we first obtained a relation between blackness rating and luminance contrast using a simple concetric circular stimulus which is called a 'blackness matching box', and then measured perceived blackness in digital images of masterpieces using the blackness matching box.

In the first experiment, RGB values of the BB (Beginning of Black) level for the Art Students are lower than those for the Engineering Students, while the RGB values of the RB (Real Black) level for the two groups are about the same. Results here indicate that Art Students have more severe sensitivity in judging the category of 'black'.

In the second experiment, three factors, "high-quality axis", "mysterious axis", and "feeling of material axis", were extracted. Art Students were more sensitive than Engineering Students in evaluating images along the "high-quality axis" and "mysterious axis", while the opposite tendency was observed in the evaluation along the "feeling of material axis". In the third experiment, when the blackness in the masterpiece images was evaluated, results of both groups showed enhancement of perceived blackness, i.e., being matched by larger luminance ratio of blackness matching box than the real luminance ratio of the masterpiece images. The degree of enhancement in the Art Students is larger than that in the Engineering Students. These results indicate that observer's interest, knowledge, and experience on arts affect on the perception of blackness, especially in the images with artistic contents.

# Evaluation of the performance of reflective e-books under different illuminations

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## Abstract

The reflective e-book (electronic book) medium has become a popular display device in recent years. It is anticipated that it will replace some of traditional paper media such as newspaper and magazine in the near future. It is thought that changes of illumination condition and viewing geometry possibly influence the visual performance of reflective e-book readers. The aim of this research was to evaluate the performances of reflective black-and-white e-book using electronic ink and colour e-book using Cholesteric Liquid Crystal, under varying illumination conditions. Furthermore, their performances were analyzed in comparison with hardcopy outputted by inkjet printers. A psychophysical experiment was carried out to evaluate the performances of the test e-books in terms of image quality and readability. Readability included the evaluation items of legibility, text resolution, and text quality. The experiment evaluated four independent variables, i.e. illumination, display medium, contrast, and resolution. The illumination conditions included three-primary colour LED, five- primary colour LED, white LED driven with alternating current, and CWF. The illuminace and correlated colour temperature of all illuminations were set to the same, 800 lux and 3600 K. Hardcopies were printed out as 3 levels of contrast (i.e. high, middle, low). The resolutions of e-books and hardcopies were set to 150 dpi and 600 dpi, respectively. Display medium included two kinds of reflective e-books (i.e. black-and-white and colour) and two kinds of paper media for hardcopies, coated and uncoated paper. In total, there were 7 display medium conditions, black-and-white e-book, colour e-book, coated paper with high contrast; coated paper with middle contrast; uncoated paper with middle contrast; coated paper with low contrast; uncoated paper with low contrast. Participants followed the instructions to assess all of the display medium conditions under the four illumination conditions. According the results, display condition had a statistically significant effect on image quality, text quality and perceived text resolution. The statistical difference was, however, due to a significantly higher perceived quality of coated paper with high contrast. Illumination had no significant effect on performance of all display medium conditions except colour image quality. In the conclusions, the ergonomic evaluations of black-and-white and colour e-books in this work revealed that the current resolution setting on e-books was good enough to compete with office paper for reading. However, the current contrast still needs to be improved for both text reading and picture showing. Using LEDs to view a colour image on display media is at least as good, if not better than using traditional CWF.

# Sparkles, colours and other light effects.
# The problem of the photographic reproduction of mosaic

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## Abstract

The paper deals with the photographic technologies and the history of the art publishing in colour. The main aim is to discuss the role of colour and light in mosaic alongside the application of colour photography and colour printing in reproducing mosaic.

Colour and light are two of the most important features in the art of mosaic and in the technique of colour photography. Byzantine and contemporary mosaics are characterized by the use of small pieces of glass or marble, vividly coloured. A mosaic surface has a complex and variable interaction with the incident light, due to the highly reflective materials used, to the tesserae's inclination and to the shape of the surfaces.

After having given a description of the main features of the mosaic and its interaction with the light, according to historical sources and to the human visual appearance, the paper treats the questions from two points of view, a historical approach and an experimental approach.

The historical approach provides a brief history of the photographic reproduction of mosaic, highlighting the major difficulties in representing the variety of colours and light effects which characterizes a mosaic surface. The analysis takes into consideration the art publishing from the beginning of the twentieth century up to the application of the digital technologies, discussing the practice of printing in gold to reproduce gold tesserae of the backgrounds. The analysis shows how the reproduction of mosaic is more problematic than the reproduction of other art techniques, like fresco, pastel or oil on canvas.

The experimental approach deals with the reproduction of mosaic by means of the High Dynamic Range Photography. The test's primary objective is that of exploring the possibilities of developing a methodology that could be used to realize cheap, easy-to-do and "accurate" images.

The results of the experiments are described showing how the High Dynamic Range Photography could be a valid help in reproducing mosaic, solving some problems of the light's sparkles and allowing a more precise description of the surface of the tesserae.

The High Dynamic Range Photography is also a valid help to take images in natural light, the illumination under which the object is usually presented, avoiding artefact illuminations that arrange the mosaic in a different settings than the one perceived by the observer.

# Colour constancy through textile veils

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## Abstract

One of the most evident effects produced by a veil on the perception of the objects in the back is the edge contrast reduction, along with a reduction of the colours differences of the objects seen through the veil. In this study we used real veils to show that, contrary to results of other researchers, constancy of colours seen through them is rather poor. A series of 10 coloured veils were placed in front of and completely covering a visual scene made of one out of three Mondrian with 9 differently coloured regions. Three different Mondrians were used to avoid the influence of memory on the reproduction of colours. Observers had to match the colours seen through the veil in an uncovered Mondrian presented in a monitor screen. The control test without veils showed a rather good performance in the colour matching, given the little experience of the observers and the distance between the two Mondrians to be matched, and the average error was of about $\Delta E^*=4.2$ for one Mondrian, and of $\Delta E^*=7.3$ for the other two. The colours reproduced when the veils were at their place showed deviations about twice times larger than in the controls ($\Delta E^*=14.6$ on the average). First, colour differences most often occurred in the direction of the reduction colours (the colours of the overlapping area seen in isolation from the context), although the difference between matched and reduction colours was quite high (around $\Delta E^*=70$ on the average). Secondly, colour differences depended also on an interaction between the veil and the background colours; for instance, light veils produce larger colour differences than dark veils, and when the colours of the veil and of a particular area of Mondrian are the same, the matched colour appears more chromatic (on the contrary much less chromatic or even achromatic when the two colours are opposed). Lastly colour deviations are substantial of chromatic type, as very little of the error is due to lightness difference. Most observers reported that the veils in the whole appeared very transparent, and this was probably due to their low luminance. The results are in good agreement with Metelli's model of phenomenal transparency, although his model did not include the case of background colours completely covered by the veils (in our case only the general white background was partially covered). Next step will check whether lighter veils induce larger colour differences, that is less colour constancy, and whether the direction of the errors is more accentuated towards the reduction colours.

# Colour constancy in natural and unnatural images

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## Abstract

It has been suggested that recognizing a room as a three dimensional space is important for colour constancy, and that in a two-dimensional photograph is lower (Mizokami, Ikeda, & Shinoda, 2004). We also showed that naturalness in the spatial structure of an environment influenced to colour constancy (Mizokami & Yaguchi, 2007). In the case of cartoon images, their unnatural appearance due to less three-dimensional information (such as shading, texture and depth) would result in weaker spatial recognition in it. It is predicted that colour constancy in those image would be lower than that in a photograph. Here we examine how the state of colour constancy changes depending on the naturalness of images by comparing a photograph with richer information of a natural scene and images with less natural information, such as cartoon and jumbled images.

We prepared the photographs of a room taken under fluorescent lamps with correlated colour temperature 2700K. A cartoon and a morphed image between the original and the cartoon were created from the original photograph as well as jumbled images, to examine the degree of colour constancy in images with different naturalness. Each image included colour patches inside and one of those was used as a test stimulus for colour judgement. In the experiment, an observer viewed an image on a CRT display in an otherwise dark room and adjusted colour of the stimulus to appear neutral by changing its colour along the black body locus In one session, five images were presented in random order. Four observers participated and repeated fifteen settings each.

Results show that colour constancy in the original photograph is generally the highest and that in the cartoon image is lower. There are larger individual differences for morphed and jumbled images, suggesting that recognitions for those images were rather unstable and depended on which clue each observer used for their judgements. Some observers show the high degree of colour constancy in the morphed images. This result is consistent with an impression reported by some observers, which the depth of the scene appeared to be more emphasized. It is possibly due to the existence of information on texture, shadings, and enhanced contour. Although the results for jumbled images do not show strong trends, colour constancy in the jumbled cartoon is lower than the jumbled photograph which is similar to those in the original photograph and the cartoon image.

To summarize, it was shown that colour constancy was lower in a cartoon image compared to a normal photograph, suggesting that natural information such as texture and shading would be important for three-dimensional recognition and colour constancy.

# Psychological relationship between colour difference scales and colour rendering scales

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## Abstract

The prediction of observer judgements about the colour appearance of typical objects under a test light source is crucial in order to characterize the colour rendering of that test light source. In the last step of the current standard colour rendering method, the colour rendering index (R) of a test light source is computed from a predicted colour difference ($\Delta E$) of a test colour sample between the test light source and the reference light source: $R=100-4.6\Delta E$. Latter formula is defined on a technological basis. But authors believe that this last step should carry a psychological meaning. It should be a prediction of the observer's judgement Rp about the colour difference quantified e.g. by CIECAM02-UCS ($\Delta EUCS$). Aim of the present work is to explore the psychological relationship Rp($\Delta EUCS$) to help interpret the colour rendering index for non-expert users. To this end, a new experimental method was built. Light sources included one incandescent reference light source and nine test light sources of different colour rendering properties ($20<Ra<100$). Homogeneous colour patches, fresh fruits and flowers and the observer's hand were assessed visually under the test and reference light sources. Observers had to judge the similarity of each test object between the test and reference colour appearance by setting a slider on a continuous similarity judgement scale between 1.0 and 6.0. Even values were assigned categories (1=very good, 2=good, 3=mediocre, 4=poor, 5=bad, 6=very bad). The resulting mean Rp($\Delta EUCS$) function of 15 observers can be seen in the Figure below. As can be seen, there is a nonlinear psychological relationship between colour difference scales and colour rendering scales.
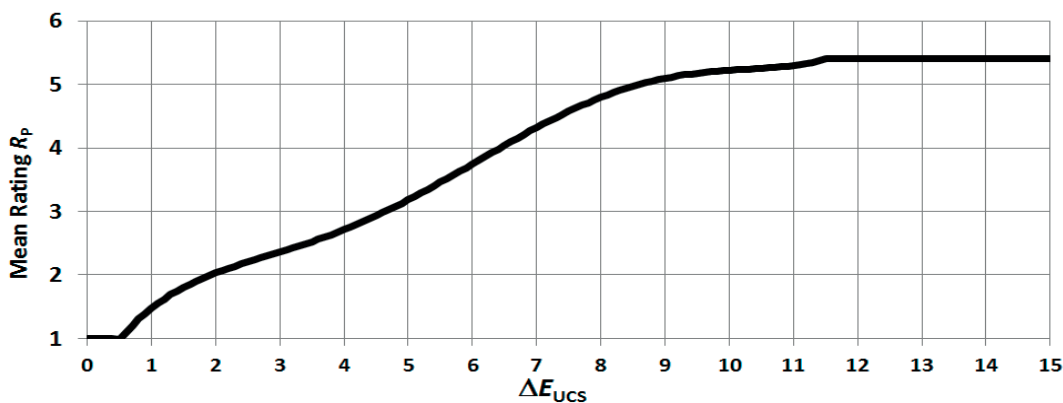
# Harmonious color group characterized by a colored light source

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## Abstract

How can a harmonious color arrangement be achieved? This has been one of the essential questions in the field of color science. Although a large number of studies have focused on this topic, there are still arguments about the nature of color harmony. Color is obviously important for design practices in any of built environments and industrial products. A systematic method producing harmonious color arrangement is worth investigating both in scientific and practical purposes. In this study we examined a simple and scientific method of producing a group of colors which appeared to be harmonious using colored light sources.

Many theories of color harmony suggested that colors having a similar visual attribute such as hue or chroma would appear harmonious. We extended this rule to visual characteristics produced by a colored light source. That is, color surfaces illuminated by a colored light are changed in a similar way according to the color of the light. A red light source, for example, will add reddish components to each of color surfaces and reduce their greenish components. If we recognize its visual characteristics shared in the group of colors, we may perceive them as harmonious. We examined this idea by conducting a psychological experiment.

In our experimental setup, an arrangement of color chips was illuminated by a colored light source. A white screen board with apertures arranged in a two dimensional array placed between a subject and the color arrangement. The subject viewed the color arrangement monocularly through a small viewing aperture. Using this setting, the subject saw each of colors in the arrangement at the location of each of corresponding apertures on the white screen illuminated by a white light. That is, the subject viewed the color arrangement as if it was placed on the white screen under the white light. The sizes of color arrangements were 1x2, 2x2, 3x3 and 4x4. We prepared 22 color arrangements for each of 4 array sizes by selecting colors from a large set of color chips. Since colors were chosen randomly, the color arrangements under the white light expected to be less harmonious. Ten subjects from Kyoto University participated in the experiment. They evaluated the degree of color harmony and their preference for each of the color arrangements.

The result clearly showed that the color arrangements under the colored light condition were given higher scores of color harmony than those under the white light condition. This indicates that colors characterized by a colored light will likely appear to be harmonious. The finding in this study will be considered in relation to a mechanism of color harmony and its possible application.

# Successive approximation in full scale rooms. Colour and light research starting from design experience

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## Abstract

The spatial interaction of colour and light is multidimensional and very difficult to capture in controlled experimental situations. Most research on colour and light in rooms has concentrated on one or a few aspects, striving to keep other parameters constant. OPTIMA is a pilot study attempting to involve all visual aspects of the room simultaneously, with an analysis starting from the totality instead of dividing it into different parameters. Its primary aim is to develop and test methods for this, derived from the practices of art and design. In a longer perspective we aim to improve the understanding of how artificial light, daylight and the shape and colours of the room interact in achieving different qualities, and the possible conflicts between these qualities.

OPTIMA uses the following method of *successive approximation*:
1. Criteria for different aspects of 'good' colour and light design are formulated by a multi-disciplinary research group. They include specified demands for positive room atmosphere, functional room qualities, low energy consumption and good colour rendering.
2. In a full scale room a team of experienced colour and light designers get the task to meet all given criteria as well as possible, starting from their own experience and without basing their choices on photometric measurements.
3. The finished test room is documented through measuring photometric values and energy consumption and evaluated functionally and aesthetically by observers.
4. The observers' performances and assessments are used as the basis for a discussion between the designers and other members of the research group. This leads to adjustments of the room – repainting, changes of illuminant quality or placement, additions or removals of such as textiles or pictures. The final decisions about adjustments are taken by the designers, based on their experience.
5. Restart of stages 3 and 4. This is done several times.

Through this procedure the room is gradually made to meet more and more of the given criteria, and the research team gradually understands how different aspects of colour and light can work with or against each other in creating the totality of the room. The important results are those obtained during the process, which reveals interaction effects that could not have been found with a method investigating one aspect at a time. The results are expressed in a qualitative mode which formulates design experience and poses questions and hypotheses that can be further investigated with more specific methods. The project is still not finished, but in June we will present:
– Methodological results – evaluation of *successive approximation based on design experience* as a method for studying the spatial interaction of colour and light.
– Findings regarding the interaction of colour and light in the specific room and discussion about their relevance in other spatial situations.

# Lighting colors for cognitive performance

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## Abstract

In order to investigate effects of color of LED lighting on people's performance on cognitive tasks, we conducted two empirical studies. Seven ambient lightings were facilitated by LED. In experiment I (N=19), we recorded brain waves using an Electroencephalogram (EEG) while subjects were focusing on two types of cognitive tasks, arithmetic and geometry questionnaires. Seven ambient lighting conditions- white, red, green, blue, yellow, cyan, and purple-were provided in random order. Additionally, table lamp was placed on the desk. In experiment I, based on the EEG records at first, we calculated the ratio of Sensory Motor Rhythm (12~15Hz; SMR: related to one's status of comfortable attention) waves to the entire range (0.5~50Hz). The results showed that the yellow ambient lighting was the best. However, we failed to find any statistically significant difference in different lighting conditions ($p>0.05$). Furthermore, there was no statistical evidence as to whether math performance was affected by the lighting conditions ($p>0.05$) or not.

As the lighting quality conditions that the subjects perceived in experiment I did not differ from each other due to the table lamp, when we conducted experiment II, we set up a lighting room in which the subjects were asked to watching a 50-inch-LED display sitting on a sofa (N=19). The subjects were exposed to all eight ambient lighting—the orange was added to the seven colors in experiment I. Under each lighting condition, the subjects read an essay displayed on the display for 120 seconds and then closed their eyes for 15 seconds between the lightings. After the reading session was over, they assessed the quality of eight lighting conditions in aspect of readability, pleasure, and arousal. In experiment II, not only the ratios of SMR waves but also the ratios of Alpha (7~13Hz; related to one's relaxing status) and High-Beta (20~30Hz; related to one's stressful status) waves were analyzed. We first found that the ratios of SMR and Alpha waves were positively correlated ($r=0.98$, $p<0.05$) whereas the ratios of SMR and High-Beta waves were negatively correlated ($r=-0.77$, $p<0.05$). The ratios of SMR under blue and purple lightings were the highest and the ratios of High-Beta of them were the lowest ($p<0.05$). This implies that blue or purple lighting provides an optimal condition for paying attention to the cognitive activity such as reading an essay. In addition, when the LED lighting was turned off, the ratio of SMR was the lowest and that of High-Beta was the highest. However, the survey results showed that yellow or white lightings should be the best and red to be the worst. Therefore, we reported the effects of lighting color on cognitive performance. Last but not least, we are to address the incongruence between one's brain activity and survey results.

# Color and cesia: The interaction of light and color

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## Abstract

Color and cesia are closely connected because of their relationship with light; both are different aspects of the perception of light that contribute to the visual appearance of objects. Color is the perception of the *spectral* distribution of light. Cesia is the perception of the *spatial* distribution of light; it is about how we perceive light that is reflected or transmitted by objects, either diffusely or regularly. In both color and cesia there is a relationship between stimulus and sensation, which is not fixed but depends on three main factors —illumination, object and observer— and is affected by many other factors such as context, adaptation, contrast, etc. The classical variables of color are *hue*, *saturation* and *lightness*. The variables of cesia are: degree of *permeability* to light, degree of *diffusivity* of light, and level of *lightness*. The variable of lightness is shared both by color and cesia, and it is the link that connect both phenomena. Fridell Anter characterized two classes of color presented by objects or surfaces: *inherent color* and *perceived color*. It is possible to apply the same concepts to cesia, where we can also recognize *inherent cesias* and *perceived cesias*. A clear transparent glass has an inherent cesia that we may define, for example, as: permeability 95, diffusivity 0, lightness 95. But the same glass may be seen with different perceived cesias according to the conditions of illumination and observation; for instance, it can be seen like a mirror if the illumination is higher from the side of the observer than from the opposite. The present paper is aimed at developing and explaining, through the methodic photographic recording of cases under study and visual comparisons, some of the following questions or phenomena produced by the interaction of color and cesia:

- Why a black glossy surface is perceived darker than a black matte surface? Why any color on a matte surface becomes darker if that surface is given a glossy finish?
- Why a very glossy black surface can reflect a colorful scene with a higher degree of contrast and detail than a very glossy white surface?
- How very glossy surfaces of different colors reflect a certain scene? How the color of the glossy surface affects the colors of the reflected scene?
- Why a chromatic color on a surface with a matte finish becomes more saturated when its surface is given a glossy finish? It is a well-known fact that the Munsell atlas with glossy samples contains a larger number of samples than the atlas with matte samples, because the glossy samples reach a higher chroma.
- What is the degree of variability of the perceived color on an opaque matte surface due to changes in illumination? If this surface is glossy instead, the degree of variability of the perceived color will be higher or lower?
- What is the degree of variability of the perceived color on an opaque matte surface due to changes in the angle of observation? If that surface is glossy instead, the degree of variability of the perceived color will be higher or lower?
- What is the degree of variability of the perceived color on a transparent color surface in the same conditions as before? And what happens if it is a mirror?

# PERCIFAL: Visual analysis of space, light and colour

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## Abstract

Two essential aspects of spatial experience, which are among the most difficult to record and describe accurately, are light and colour. PERCIFAL aims at capturing the total visual perceptive experiences of architectural space in a form that can later be compared and analyzed. The method is based on direct visual observations and the recording of these observations by verbal-semantic descriptions using a questionnaire. The questionnaire is divided into the following eight main topics: 1) General impression of the space, 2) Overall level of light 3) Light distribution in the space, 4) Shadows and flecks of light, 5) Reflections and glare, 6) Colour of light, 7) Surface colours, 8) Interaction of space, objects and people.

PERCIFAL (Perceptive Spatial Analysis of Colour and Light), which is a subproject within the Nordic research project *SYN-TES*, has been developed primarily as an educational tool, but we also see in it potential as a design tool for professionals and as an analytical method for research. Drawing, painting and photography, the conventional methods for recording experience of light and colour in space, are able to convey much of their total layout and atmosphere, but cannot communicate accurate information about surface colours or levels of illumination. These can be recorded and communicated more accurately by photometry and colour sample matching, but these methods tell us nothing about the spatial context (and therefore the experience) of the measured colours and lights. We experience colour and light as a result of perceptual adjustment and adaption in spatial situations. These situations are highly complex: as we move around and through a space, successive and simultaneous contrast effects, as well as global and local brightness and colour adaption, affect the way we perceive and experience the spatial totality and its parts. Such visual experiences as lightness, brightness, highlight, glare, colour and shadow cannot be captured or communicated by measuring. They are relational qualities that arise from the subject's participation and action in space. All existing methods tend to reduce the temporal and multidimensional experience of space into either static flat images or abstract alphanumerical data.

The first test results of PERCIFAL, conducted in Sweden, Norway and Finland, show that the method has significant pedagogical merits and that it can reveal significant and interesting discrepancies between photometric measurements and our visual experience of space, light and colour.

# Erwin Redl or the matrix indexing of space

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## Abstract

Light is probably one of the most ambiguous and universal medias available to today's visual artists. The way it is used varies tremendously from an artist to another.

Erwin Redl's work summarises in a subtle and minimalistic manner the mediality of light used as a visual medium of its own right. Since 1997 he has investigated the term of 'reverse engineering' in order to translate:

> *"the abstract aesthetic language of virtual reality and 3-D computer modelling back into an architectural environment by means of large-scale light installations. In [his] work, space is experienced as a second skin, our social skin, which is transformed through my artistic intervention."*

By doing so Redl aims to reduce the viewers' interpretive concerns to the sole notation of our sensations, he forces them to realise how his shimmering immersive installations affect their bodies through the haptic nature of light and the minimalistic geometric design of his artworks:

> *"Due to the very nature of its architectural dimension, participating by simply being "present" is an integral part of the installations. Visual perception has to work in conjunction with corporeal motion, and the passage of time, an additional parameter of motion."*

It's as if after extended looking, we need to recalibrate our senses to our form by experiencing the uncanny materiality of light that becomes here more than a simple visual sensation, but a physical experience. Therefore the term aesthesics should be preferred to aesthetics to describe Redl's work.

In his installations, wall to wall and floor to ceiling the exhibiting space is filled with grids of LED, creating a pulsating visual network that enacts both the amplitude and regularity implied by all the meanings of the word matrix.

Controlling the modulation of light with a computer program, Redl generates a perpetual system of repetition:

> *"The formal aspect of the works is easily accessible. An interpretation and understanding of this aspect is dependent upon the viewer's subjective references. Equally, the various individual's interactions within the context of the installation re-shape each viewer's subjective references and reveal a complex social phenomenon."*

This constant fluctuation plunges the viewer in both introspective and detailed observation of an abstract 'lightscape', observation that cannot be completed or reproduced. Paradoxically, if one examines the oscillating light carefully, the methodical movement begins to mesmerise one's attentive gaze. Redl's work with light is akin to watching the subtle, licking flames of a fire; one can easily get lost and overwhelmed in the nuances of perception. Rhythm, periodicity and luminescence are definitively the artist's forte.

# Light focusing on design in society and working life

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## Abstract

The objective of the project is to study and analyse Design approaches and methods in complex situations, such as public and urban settings and furthermore territorial development strategy, thus exploring the possibilities of creating light and colour solutions that take into account both function, ergonomics, psychological and emotional aspects in public surroundings. It also aims to highlight the design process as a possible methodology for product and service development.

The project stepped out from an initiative launched by the Swedish Ministry of Culture, to encourage the development and spread of design within the country and was the premise to the ongoing research LCS-light, colour and space.

The project made use of a design methodology named ITK – Identity Tool Kit –, in a completely new context, and also of models of the selected locations. It further involved various groups of people in the process, where the figure of the designer was seen as the central figure within teams made up by students, artists, professionals, political representatives and businessmen cooperating inside an extended network.

A 'Light Year' was set up on the basis of a series of considerations spreading over several domains implied in Design discipline, where a knowledge platform was built and design methods were studied. Throughout the course of the Light Year several communication, technical, artistic and educational events including workshops, conferences and other temporary or permanent initiatives were implemented. Then full scale models in the territory followed.

Examining the final results of this broad project several positive facts indicate that the main goal of the project, of moving beyond light and colour design and showing the usefulness of design and design method so that design is perceived to be essential for everyone in work and at leisure, and, as well, knowingly work with design and business development and strategic approach, was achieved.

The purpose of the Light year, of clarifying the value of design in everyday life, was rewarded by the National Design Prize, and by practical issues of both permanent and temporary events such as light festivals, installations, urban lighting and urban plans, and the creation of new work places.
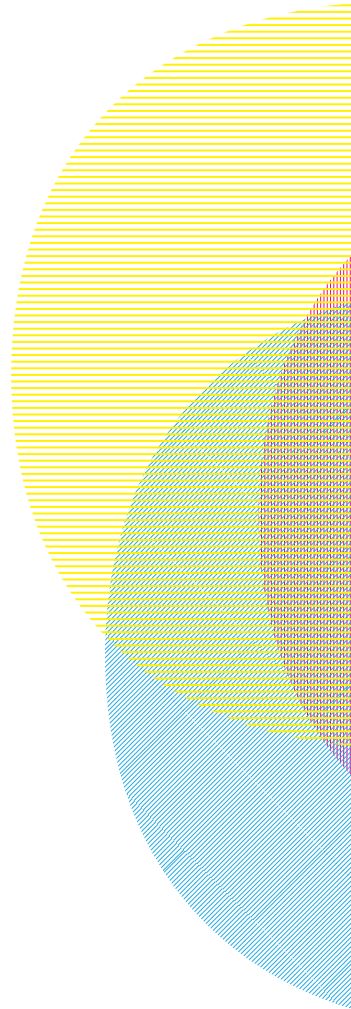
# Posters

in alphabetical order by presenting author

# Trichromatic animation

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## Abstract

The process described here is well at the heart of the appearance of pigmentary materials and their interactions with light. It is based on the property of colored materials to reflect, in a selective way, the colored radiations of light.

One knows the process of the anaglyphs, which makes it possible to suggest a relief, starting from colored prints in red and cyan, read through colored glasses.

The innovation rests here on a more subtle and more complete process, using the trichromy, i.e. all the possibilities of white light, split in three primary radiations: red – green – blue.

This process makes it possible to animate a pigmentary surface by alternate projection of these three colors. One can thus reveal three different images on the same support, or create a movement.

It is known that in the darkness, a red pigment, illuminated with red, will appear as white as a white surface, and will merge with this one. But when illuminated with blue or green, it will appear as black, and will merge with a black background.

This effect will occur in the same way with green or blue surfaces, under different colored radiations. And intermediate colors, like yellow, purple, cyan, will allow also intermediate effects. Thus the yellow will be also sensitive to the green and the red, but it becomes black under a blue lighting.

However in this process, the weakness of blue, compared to green and red, could constitute an obstacle. Blue filters indeed shall be very dark, to be sufficiently selective. That is why they let pass a very little quantity of light.

But that will be compensated by the use of fluorescent colors, instead of ordinary colors. Thus, the law of Stokes, according to which fluorescent colors shift the wavelengths re-emitted by these pigments, makes it possible to preserve a very good apparent brightness under a blue filter.

This process can provide very spectacular applications in the fields of lighting, architecture, design, scenography, booths, display windows, etc. And one can be astonished by the fact that it is practically ignored in the field of painting and exhibitions.

Examples will be shown on a setup, exhibited at the Pompidou Center of Paris, and which functioned, with a great success, during long years, at the children workshop.

# The use of matrix Q of the decomposition theory and principal component analysis for color image mapping of a scene

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## Abstract

Color scene interchange has manifold applications, for example, in modifying color of old and unpleasant photos, coloring black and white pictures, scene simulation, computer graphics, industrial design, etc. Some researchers recommend histogram rescaling of color gamuts of images. In this technique, the color gamut of the target image is compressed or spread to the gamut of a standard image. The scaling procedure is usually carried out based only on the initial and terminal points of the histogram of the target and the standard images. Therefore, the shape (distribution) of the image's histogram is not totally changed and probable noises can significantly influence the final results. In the present study, a new technique comprising of the matrix Q of the Cohen & Kappauf (C-K) decomposition theory together with PCA (principal component analysis) method is proposed as a practical tool for color image mapping of a scene. In this technique, the images of the target and the standard were captured under a desired illuminant/observer combination. Then, matrix Q of the C-K's decomposition theory is computed for the selected illuminant/observer combination. By colorimetric characterization of the utilized digital camera, a transformation matrix is obtained capable of calculation of the CIEXYZ device independent values from the corresponding RGB values. After that the RGB values of the standard image are transformed to the corresponding CIEXYZ values using the computed transforming matrix. The CIEXYZ values of the standard image are then multiplied by the matrix Q to obtain the corresponding fundamental color stimulus ($R_{fcs}$). In a further step, PCA technique is applied on the attained $R_{fcs}$ vectors of the standard image. The first three PC vectors were then considered as an Image Scene Mapping (ISM) matrix. Finally, the $R_{fcs}$ vectors of the target image were reconstructed using the computed ISM matrix.

By so doing it is possible to map the scene of the target image into a standard one. The obtained results show that the proposed method can precisely transform the scene of one image to another.

# New photometric device for discrete angular measurement. Experimental validation by analysis of the glare on buildings

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## Abstract

In this work a new photometric device is presented. This new device measures, simultaneously, the total incident illumination and the relative percentage contribution to this amount of each incident direction. The device also allows the measure of the glare on buildings due to outdoor and indoor artificial lights.

The photometric measure is done by means of a set of photodiodes and an optical system with a 2Mp sensor. The set of photodiodes measures the total amount of light at high frequency speed with high dynamic range photometric values. The optical system is a wide-angle optic of 180º FOV focused at infinity that provides information of all the directions over the hemisphere.

The 2Mp sensor working with the 180º FOV optical system has an angular of 0.25º for any angular position that we can choose, at the same time the current level of each pixel (digitalized at 256 discrete levels) gives information of the amount of energy that arrives from each corresponding direction. Finally, custom-made software analyses all the information and gives the result of the illumination measurement.

With this new device illuminations maps can be made with more information, that the actual ones, allowing to know the contribution of each lighting element to an illumination scene. The results obtained with this device are of interest to measure stray light, glare effects and light pollution. The possibility of knowing the origin and the amount of energy at a spatial point allow as to analyze complex environments and make energy-saving plans, as well as illumination efficiency and visual ergonomic studies.

The presented device has been experimentally validated by means of the study and the analysis of glare in indoor conditions.

# A portable assistance tool for color vision defectives with real-time color changing function

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## Abstract

In order to improve the quality of life (QOL) of people with color vision deficiency, versatile color vision assistance tools that can be used anywhere at any time are required. We have developed a portable real-time color assistance tool that is compatible with most commonly used digital devices.

First, a color changing method, which modifies color to help dichromats improve in discrimination and visibility, is proposed. We define a "color zone" as a unit of changing color; it is a continuous subset of three-dimensional color space. All colors within one color zone are changed simultaneously. The location of a color zone can be shifted automatically or interactively. It is known that dichromats perceive colors only on the color projection plane in LMS color space. A color zone is defined as a region between planes that are parallel to the color projection plane. The parallel plane make a group of lines in the u'v' chromaticity diagram that converge at one point. Thus, the color zone is a wedge-shaped area in the u'v' chromaticity diagram. The chromaticity or the lightness of the original colors is changed in the color zone.

Next, the color changing method is implemented on an iPhone (portable smart phone device) as a color assistance tool. A series of calculations are performed on a GPU (Graphic Processing Unit) to increase the speed of the color change. A built-in camera captures 320 x 480 moving color images in 15 fps, changes the color in real-time, and displays them on the screen.

We examined whether the proposed method would work properly or not, and evaluated the effectiveness of the color assistance tool in two ways. We used two photos as visual targets: the Ishihara plate and a photo of a flowerbed. On Examination 1: color-normal observers evaluated the method using a simulator for defective color (dichromat vision). Numeric letters in the Ishihara plates were clearly recognized and red flowers in a flowerbed were easily noticed after changing the chromaticity or the lightness. On Examination 2: Four test subjects, (a protanope, a deuteranope, a protanomaly, and a deuteranomaly) evaluated the same pictures. After changing the chromaticity or the lightness using the color assistance tool, all subjects were able to recognize every letter in the Ishihara plates, and were also able to notice red flowers in the flowerbed.

Our color changing method improved discrimination and visibility for a protanope, a deuteranope, a protanomaly and a deuteranomaly. It is an effective color vision assistance tool that can be implemented on portable devices that users always carry in their daily life, such as a cell phone or a digital music player.

# Dvelopment of multi-angle spectral imaging system using LED illuminant – LCTF device and analysis of Japanese silk textiles

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## Abstract

Spatial Reflectance Distribution such like various of Specula or diffuse Reflection are very important property for the value of design. A lot of silk woven techniques can be seen for Japanese costume Kimono. It is a simple shape geometrically flat stitched textile that has kept almost same format for over 1000 years. It is in the form of 'body wrap' instead of 'box in.' Therefore, it changes the shape according to human body and movement. On the other hand, textures of textiles are various. This variety depends on complex combination of material and technique about yarn-making process, weaving, dyeing, embroidery, and sewing. The Purpose of this study is to investigate the impression as a reaction to texture by separating the unity of comprehensive impression to each scene of ray. This presentation was reported the case of 'Rinzu.'

According to this purpose, Multi-Angle Spectral Imaging system was developed. It has 6 LED Illuminates that emit the sample by 30 degree unit between -75 to 75 degree from vertical direction of sample, Liquid Crystalline Tuneable Filter (LCTF) and CCD device to capture the sample. This System can measure gonio-photometric and visible range Spectral Image radiance factor from 420 to 700nm by each 10nm unit. Distribution on CIELAB Color Space is calculated from these spectral information and applied analysis of several fabrics Characteristics. Also brightness and each wave length radians factor distribution in Images were calculated and was researched correlation between human sense of texture and number of Distribution.

Analysing the images of 'Rinzu' sample from a different angle measurement, it seems like plain colour at 15 degree Illuminate because it reduce the difference in the shadow. Textile patterns are revealed in rich shade at 75 degree because it spreads the differences. Positive and negative inversion can be seen in the incomplete state at 45 degree Illuminate. 'Rinzu' is characterized that emerge polymorphism change with glossy shape by weaving and condition of wearer. Human visual system works by detecting the difference of stimuli. Sensory threshold is adjusted depending on the width difference between the maximum and minimum, we feel complex impression in the case of see the combination of different set of subtle differences at the same time. Typical points of spatial recognition in Japanese culture are shift of meaning / horizontal base / obscurity. Aesthetics of 'obscurity' has been nurtured by a traditional living environment that is surrounded by trees, grass and paper, and indirect sunlight or dim flame. It influenced also clothes.

Normally we feel a comprehensive impression at the impression of a continuous surface. Separating those unities to each scene with this device, it assists to find the effective patterns that utilize the appeal of the movement and shape of the body.

# Eye-catching colors using eye tracking in a mobile communication context

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## Abstract

The purpose of this study was to find eye-catching colors and to provide empirical grounds for strengthening the visual information structure. Eye-tracking experiments considering the unique characteristics of mobile use were conducted. The experiment was divided into three parts.

Each stimulus consisted of 25 identically sized color chips in a 5 by 5 matrix. Black was used as a background color, as it is the normal background color of a mobile phone screen. To control for a background effect, each stimulus was also tested with a white background. All stimuli were displayed on the monitor for seven seconds, and a break of two seconds was inserted before the next stimulus to prevent an afterimage effect. The subjects were 15 college students of both genders. They were asked to select their preferred color from among 25 colors to determine if there was a correlation between the colors that attracted their attention and their stated preferred color. In this way, the concentration of the participants was continually focused on the experiments. For the analysis, the first three seconds were investigated to detect the eye-catching colors.

Part I was intended to determine which hue catches the eye. Accordingly, 25 different hues of the same tone were shown together. A total of 25 hues in each tone (vivid/ light/ dark/ moderate tones) were randomly arranged in three different ways to avoid position bias. In contrast to Part I, Part II sought to determine the tone that initially attracted the visual attention. Therefore, 25 different tones with the same hue (red, blue, and gray) were tested together. Samples with the same hue were randomly arranged in three different ways to avoid position bias. Single-color chips were used for Part I and Part II, whereas Part III was conducted with two-color combinations: an icon color and a background color. This part sought to investigate whether color combinations have an influence on participants' attention in a manner different from that of single colors. For comparison between single colors and two-color combinations, 6 stimuli in the vivid tone of Part I were used as background colors for this part. Red, green, and blue icons were added to each single-color background.

The findings from the three-part eye-tracking experiment can be summarized as follows. First, warm colors are more eye-catching than cool colors. Second, colors arranged along the horizontal and vertical axes hold the attention easily. Third, a design using complementary colors will gain a person's attention. This study can lead to better planning when using colors with a specific contextual aim in mind. The results of this research can be useful to mobile GUI designers as they seek to apply colors properly.

# Color change of objects controlling spectral distribution of light and spectral reflectivity of color material

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## Abstract

Object's color is determined by the combination of spectral distributions of light and spectral reflectivity of color material. In general, good color rendition is favorable feature of illumination and color appearance change of the object under different illumination should be avoided. As in the case of choice of dress, customers will be bewildered if the color of the dress changed when they wear the dress and go out of the clothing shop.

On the other hand, color change is very attractive as in the case of blinking neon signs and color change of the actor and actress or stage settings in the color spotlights on the theater. So, if we change our point of view, color change of objects under different illumination could be very attractive production if we use it in an effective manner. Color changes of the objects in the color spotlights are effective to some extent but are not so amazing because of color constancy. However if the color of the object changes in the same color light especially in the white light we would be surprised and stare into the object. So if we can change color appearance of the food at will under white illumination it will be good and mysterious performance for the restaurant patrons.

In this study we try to find out color change of objects using data of many white lights with different spectral distribution and data of color materials with characteristic spectral reflectivity on our color simulator. We prepare 78 white lights with different spectral distributions. Each of 78 white lights is consisted of three peaks within the wavelength from 410 nm to 670nm with 10 nm increments and each peak values are controlled to make white lights. As color materials we pare spectral reflectivity data of typical oil paint and some Japanese traditional dye goods.

As a result, we found out many clear color change color materials within the particular pairs of white Light and color materials. In the case of "yellow ocher", for example, color appearance changed red to green continuously depend on the spectral distributions of the white lights. In the case of Japanese traditional dye goods there is one which color changed green, orange, purple and grey very clearly.

According to the results of the simulation, then we have made substantiative experiments in order to make sure that the object color changes practically using real light sources and real color materials. The results of the substantiative experiments showed us that many color changes we found out on the color simulator can be seen actually using real lights and real color materials.

These results of our study suggest that we can realize clear color change by controlling spectral distributions of light without being aware of illumination color change. We can utilize this clear color change in our method as an effective and attractive display of the commercial products or as a fantastic change of interiors of the room or scene changes of the stage only with calculated changes of illumination.

# A perceptual approach to the chromatic complexity of contemporary city

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## Abstract

The perceptual impression evoked by an urban environment, even if consisting of identifiable series of elements, lies in the quantitative and qualitative interactions among the various elements. In analyzing the colour of an urban area, then, it is not sufficient to proceed in "punctual" terms, as if it were a summation of individual colour components, instead it should be preferable to think in terms of chromatic spatial context leading to highlight, as noted by Lenclos, that system of variables – light, material, shape, size, close by and distant colours – that determines our perceptual experience of places.

The aim of this paper is to present the first results of a research finalized to outline and verify a method of reading the urban colour component based on the perceptual data. For this purpose a circumscribed urban area, a square on the outskirts of Milan, was identified as a case study on which conduct colour readings in relation to the different spatial conditions.

Analysis of different spatial conditions was determined by a study of flows and preferential positions of observation that covers the distance, the direction and also the different perspective, which is offered to the observer in motion than to the static observer.

On the basis of the paths and observation points identified, then, a photographic survey was conducted that, through a sort of collage, returns the most common looks and experiences within the square. And it is still from the viewpoints identified that observations of colour, in different times of the day and under different weather conditions, have been carried out.

This research begins from a series of considerations with respect to the practice consolidated in the colour plans of Italian history, and is based on the belief that the perceptual data is the one actually useful in order to launch a design reflection on urban colour. The method outlined, although still subjected to validation and implementation, is proposed as an alternative to the established practice of conducting inherent colour surveys that not only require specific tools, but also the possibility to reach all surfaces to be surveyed. It is only in a more advanced phase of the plan process and whereas it is believed to work in conservative terms toward the colour presences, in fact, that a specific and punctual colour survey is needed in order to a conservation of the chromatic matter of historical building, as element of material culture, or a faithful remake, as element of collective memory.

# Colorimetric characteristic of ink jet prints in function of environmental parameter

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## Abstract

Ink jet technology is the printing technology using the ink droplets without the contact with the printing substrate. The ink droplets are sprayed through the nozzles on the substrate to obtain the image. Durability of color prints has steadily improved. Improvements have targeted the following areas: lightfastness, thermostability, water-fastness, humidity-fastness, and pollution gas-fastness. Light fastness is one of the most important items in ink jet printing.

The purpose of this paper is the result presentation of the gamut volume and color difference ΔE research of ink jet prints exposed to outdoor conditions and accelerated ageing. The prints obtained by piezoelectric, thermal ink jet and UV technologies were used in the research. The test form contained ISO and ECI patterns. The part containing the ECI measuring form consists of fields with different color values combination of the subtractive synthesis. It was intended for spectrophotometric analysis. The information quantity obtained by such measurements enabled the construction of 2D and 3D gamut in perceptual uniform color space. Paper declared as the poster paper for indoors and outdoors graphics and model paper were used for printing. The prints are divided into three series. In the first series the samples were exposed from the inside of the room through the glass window in the duration from 1 to 3 months. The samples in the second series were exposed to outdoor conditions. In the third series prints were exposed to accelerated ageing in Solarbox 1500e. Investigation results of the impact of outdoor conditions (winter season, sites with intensive traffic, residential area without industrial impact) on a volume of gamut prints show the dependence on kind of ink jet technology and the dynamics of exposure, as well as the substrates properties, including composition and properties of paper coatings. Ink jet prints based on ultraviolet technology exposed to outdoor conditions over time increases the volume of a gamut, but with the time of exposure ΔV was reduced. The results obtained with two other printers have opposite relationship. The paper explains the results in relation to the principle of the ink jet printing technology, and the characteristics of the substrate. The mentioned results are compared with the results obtained from accelerated aging to simulate outdoor and indoor conditions. Results show the greatest change in color for K and M.

The obtained results have proved the possibility of appreciation of the complex approach of integration to creativity by incorporating in the phase of the design and preposition of the life cycle of the graphic product, and color characteristic of the prints taking into consideration the ecological responsibility of the design in the system of sustainable development.

# Colour and light wall works in architectural space

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## Abstract

All my projects for architectural spaces reveal colour, light and again the colour in the changing light of architectural space. Within this act is the revelation of surface texture. Nature is my primary source of inspiration to create, by hand, surface textures designed specifically for each architectural space in which I work. In order to reveal colour and light, I focus on the nature of pigments and the processes of transformation and composition to allow their revelation as a surface texture. At the same time, I study the context through which I will reveal the space in colour and light. I would like to present some of my designs and artworks showing them in moments of light that reveal all their subtleties. Notably, two of my recent works in La Grande Arche de la Defense in which I pondered over the question: when is the true moment of colour? Both mural works for La Defense create a revelation of colour and light in two previously mundane corridor spaces. The transformation of these spaces through light and colour initiates new volumetric sensations and constant chromatic vibrations. They become moments of magic within the existing architecture.

Colour and texture interacting with light pre-occupies my thoughts every day in research and practise. After finishing my studies in France, (Ecole Boulle and Ecole Nationale Supérieure des Arts Décoratifs in Paris), I created a design studio twenty- seven years ago to research colour and surface textures. I create my own chromatic palettes inspired by the observation of nature and its transformations throughout the seasons. I have developed a language of colour and materiality, which I use to create large-scale wall murals and surface textures for wall paneling, furniture and objects within the domain of architecture and design. In understanding the way in which colour and texture absorbs or reflects light, giving it a specific character, I am able to create unique spaces. Our attention is first attracted by the colour and then gradually penetrates into a world of successive layers and details created by a play of light and texture. Colour becomes texture and light.

# Illuminating the psyche

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## Abstract

Mary Boochever is a fine arts professional and an IACC accredited color consultant.
Thesis title: The Use of Color in Sacred Space

Chris Stamp is a psychotherapist practicing in Manhattan and East Hampton, New York. On August 4, 2010, I conducted an interview with Chris Stamp about the use of colored lights in his psychotherapy practice. The interview was structured around the following questions:

1. What kind of psychotherapy do you practice primarily?
2. How do you incorporate colored lights into your therapy?
3. Is there a precedent for this? How did you come to use this method?
4. What correlations have you observed between color and memory?
5. Are there colors you use to soothe or stimulate?
6. What type of lights do you use?
7. Is there a particular sequence of colors that you prefer using? Can you explain?

The type of psychotherapy that Chris Stamp practices is called Psychodrama. Developed by Dr. Jacob L. Moreno, 1889 – 1974, Psychodrama incorporates strong elements of theater. Participants explore inner conflicts through acting out their emotions and interpersonal interactions, often on a stage where props can be used. A type of trance is induced where the client can move from the conscious to unconsciousness. The core function of Psychodrama is the raising of spontaneity in an adequate and functional manner. "I let them act out their conflicting roles and help them put the parts back together again." Moreno, (1912)

A psychodrama is conducted by a person, trained in the method, called a psychodrama director. The interview with Chris stamp explains the process through which the psychodrama director guides the client through a trigger occurrence to a re-enactment of past events, leading then to a crisis point and catharsis. The participant is then eased back to the present moment.

The lights that Chris Stamp uses are red, yellow, blue and green incandescent floodlights with a dimmer. They are used alone or in combinations to support and emphasize the emotional states which are being evoked; trigger occurrence, re-enactment of past events, catharsis, present moment. Colored light is also used to facilitate dream recall.

Chris Stamp's background in theater, as well as his own personal journey of self-discovery and healing, invest this otherwise little known use of color in the therapeutic environment with the vitality of a practice born from a combination of creative experience and inner necessity.

# Instrumental and sensory analysis of goniochromism

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## Abstract

Iridescent materials present striking colour changes under different illumination-viewing conditions. They are used in various domains: cosmetics, automotive…, so that their control is becoming a technological issue. The goal of this research is to develop a protocol of characterization which identifies the colour change in the existing colorimetric formalism. We based our study on a set of 32 samples, including plain, glossy and metallic ones, as a reference for iridescent ones. We characterized them both instrumentally and visually. The correlation between the results of these two characterization methods should lead to the aimed protocol. In order to investigate the different spectral responses of the materials, we used a multi-angle spectrophotometer (X-Rite MA98). To explore more measurement geometries, we used a conoscopic colorimeter (Eldim EZ-Contrast): for a given, adjustable, incidence, for every viewing angle (roughly 28800 viewing directions in a cone of 80° semi-aperture), we get the colorimetric coordinates of the light reflected in this direction. The measurement duration with a conoscopic system is much shorter than with a goniometer. The visual evaluation consists in a sensory analysis experiment. A 15-assessor panel is being trained to establish an objective, descriptive profiling of our samples. The evolution of the reflection spectrum with the measurement geometry is linked to the appearance of the sample; in the case of multilayer interference, the correlation between this evolution and the measurement geometry can give information about the orientation of the multilayers within the sample. For a given incidence, the evolution with the wavelength of the angular distribution of the reflected light in the plane of incidence is an indication of iridescence. From conoscopic colorimetric measurements we get a well-furnished cluster of points in the CIELAB space. Its topology (size, volume and shape…) is clearly linked to the appearance of the sample. A detailed study of this topology is under progress, to define a few pertinent features characteristic for iridescence, as for example 'hue variation with incidence' or 'brightness variation with observation angle.' From the sensory evaluation, our set of samples is divided in populations (sparkling or not, glossy or not...). The iridescence seems closely linked to the glossiness and the sparklingness. Our instrumental evaluation produced interesting tools to predict the appearance of a sample. The sensory analysis is producing the attributes of iridescence. The visual and the instrumental attributes will be correlated to build a protocol to characterize iridescent objects.

# Psychological study on preference of ideal skin color – comparison between Japan and China

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## Abstract

Different from the Western world, the brightness of the skin is considered as one of the most important aesthetic standards for feminine beauty in Asia. The markets for whitening cosmetics, led by Japan and China, are developing extraordinarily fast these years and take the most possession of the world market. In this study, the author tried to compare the difference of preference of ideal skin color between Japan and China.

The first experiment was taken to investigate the importance of skin brightness when Japanese and Chinese women evaluate ideal skin.108 Japanese women and 130 Chinese women took the experiment as subjects. They were asked to answer a questionnaire about skincare habits and evaluate 10 stimuli of different skin troubles on bright complexion and dark complexion by 5 levels evaluation of Semantic Difference method. The author indicates that when evaluating the ideal skin, the women in these two countries always regard the bright complexion as the top choice. In the case of China, the complexion is even more important than texture at judging the skin. On the other hand, the skin trouble which Japanese women concerns most is the pore problem, while Chinese women gave the lowest rank to the aging problem.

The second investigation was taken on 87 Japanese women and 96 Chinese women on their original skin color and ideal skin color. First, they were required to choose one color which is most similar to their own skin tone and then choose their ideal skin color from 145 colors skin tone chart which is produced by Japan Color Research Institute. Finally, we recorded the Hue, the Value and the Chroma from the forehead, cheek and neck of the subjects to do the comparison. The result of the experiments showed that as for the preference of ideal skin color, Chinese women focused more on the pink complexion than Japanese Women as a whole, while they assessed their own skin color much darker and more yellowish.

The results indicated that complexion played a key role on ideal skin evaluation in both Japan and China. But the difference between the two countries was also clarified. Chinese women showed their much more preference for skin brightness than Japanese women. And they gave priority to complexion while Japanese women valued the state of the skin most when they evaluated the skin.

# Urban policies towards façade colours

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## Abstract

Our research project develops a methodology centred on colour plans for urban environments. We have taken Rua da Junqueira, an urban historic consolidated area in Lisbon, Portugal, as case study. The present results focus on the municipal strategies for the area regarding colour for the façades of buildings. We start by presenting facts and we proceed with a critical assessment on the current policies in the context of the ongoing debate on colour plans.

Interviews conducted to municipality planners clarified that there is a multiple option strategy where building owners may choose among three possible options for painting façades. The first is to maintain the existent colour, the second to paint it in the last approved colour as shown in the municipality archives and the third to change the façade colour subjected to municipally approval but the criteria for the colour approval is not explicit. The latter requires a tax payment.

The fact that there is a strategy towards the colour of buildings means that the municipality acknowledges the need to regulate it. But a closer look at the colour strategy shows a lack of urban sense or, at best, an understanding of a lower role to colour on urban context if compared with notions such as preventing or increasing densification or the role of green areas. A strange strategy seems to arrive at an absurd stage when to enlarge an apartment or a building might pay lower taxes than to change a colour in to a colour chosen according to an urban strategy. In fact that multiple options strategy is based on colour assessment at the scale of the individual building, which means that colour in public space, is being treated as an architectural issue rather than an urban planning one. Such fragmentary analysis makes envisioning the results impossible at the street scale. We claim that the resulting street image, under the actual colour policy, is eventually not that different from the 'chaotic image' that resulted from multiple individual choices of the pre-regulated city or, it can be worse because taxation bounds individual freedom and might help to keep chaotic urban environments.

# Light, colour and texture: The appeal of the senses to improve independence among the elderly

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## Abstract

The aim of this research paper is to assert the importance of light, colour and texture in the quality of life of human beings, particularly in the performance of aged people's perception of the space. Literature review documents the importance of the colour contrast and light characteristics to individual perception of the built environment. Despite the arguments from the various authors and the results of dissimilar research projects, the planning of assisted living environments continues being supported by cultural and aesthetical principals and architectural rules which include accessibility; however, attention to the need to understand how people view and perceive the environment still lacks in order to improve individual autonomy and well being. To sustain this argument two examples will be analysed in order to understand how light, colour and texture contribute to the autonomy of aged people by improving the sense of comfort, personalisation of the place, notion of the deepest and the nearest plans, orientation within a pathway, etc. These case studies were selected because they illustrate the subjects focused on the previous statement very well. The perception of space needs the visual as much as the tactile and acoustic senses. The use of different textures can be important to people with short sightedness condition as well as the contrast between the colours applied with special emphasis to the importance of light that expose reality and influences the circadian cycle, and the incidence on surfaces that demands glare control. If this can be important to people in general and to the elderly in particular, it must be a parameter to include in the planning of standard houses to augment their ability to support the human life cycle. People have a very straightforward relation with their home, especially when they reach seniority, without interrupting the performance of their functions and interacting socially. By age, by force or by individual choice the elderly stay more time at home, thus, home environment needs to be properly cared for, in order to guarantee his/her safety and above all, comfort and motivation. To reach the mentioned objectives, the layout, finishing and especially light, stand out as the fundamental factors that will guarantee the understanding of this same space by the individual. The light and colour are the two sides of the same coin attached by texture which reduces and/or raises the jigsaw of shadows. Colour is significant, significance and signification. The presence of colour within the home environment ought to be more than just the use of the white (in the belief that this is a neutral colour and consequently its appliance is always correct) or just the use of a dated colour catalogue provided by any brand!
**Keywords:** Light, Colour, Texture, Home environment, Design

# Propagation of errors in a color-matching experiment

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## Abstract

We revisit the problem of propagation of errors in the pioneering color-matching experiment by D.L. MacAdam [1]. The observer made color-matchings by tuning the angle of a Rochon prism in order to match the fixed and the variable half-fields. The observer's settings for the angle were assumed to be distributed according to a Gaussian distribution function. The average value of the angles was considered to derive the average tristimulus values and chromaticity coordinates, whereas the standard deviation of the angles was used to derive the uncertainty interval. This procedure implicitly assumes that tristimulus values and chromaticity coordinates also obey to a Gaussian distribution function.

In this work we do not make any assumptions about the probability density function (pdf) associated to tristimulus values, and we make use of the rigorous statistical theory to derive the true pdf's associated to the tristimulus values [2]. We also analyze how much deviate the actual pdf from the Gaussian by computing the third and fourth centered moments (asymmetry and kurtosis, respectively). In addition we outline a method to derive by numerical procedures the interval of color mismatch, without making any *a priori* assumption about the symmetry of such interval. Our results are compared with those obtained by using the common approach to derive standard deviations of transformed magnitudes [3].

The method is applied to the data provided in [1] and the analysis of the numerical results reveals that the transformed pdf's deviate from the Gaussian. We also derive the uncertainty intervals for different combinations in pairs of the filters used, and they exhibit asymmetries whose ultimate origin arises from the deviation of the pdf's from the Gaussian character. The deviation between the conventional procedure and that proposed by us is shown to depend on the confidence level ($\alpha$) used: this deviation remains within acceptable values (in the order of 0.5%) for large confidence level ($\alpha$=0.32), and becomes extremely discrepant (in the order of 10-20%) for low values of the confidence level ($\alpha$=0.05).

We can summarize the main finding of our work by stating that the color-matching intervals derived from the conventional procedure of propagations of errors could significantly differ from the actual intervals which are derived by considering how the probability density functions transform from an original set of variables to another set of variables.

[1] MacAdam, D. L. 1924. Visual sensitivities to color differences in daylight. *Journal of the Optical Society of America* 32: 247.

[2] Papoulis, A., and S. U. Pillai. 2002. *Probability, random variables and stochastic processes,* Chapter 5, New York: McGraw Hill.

[3] Nimeroff, I. 1953. Propagation of errors in spectrophotometric colorimetry. *Journal of the Optical Society of America* 43: 531.

# The paths of the rainbow

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## Abstract

The interaction between material colour & light. The osmosis of paint. A new approach to painting using colour, based purely on the knowledge that governs our inherent vision of colours. Whereby Colour defines itself & we are dealing only with colour

– its double nature: luminous & material
– its permanence
– the permanence of its transformation

All of the above fall into what I call Mobil Colour Art.

This art of colour is not willingly a constructed optical art.

It claims the freedom to be in & of itself by posing the question:

What does it signify to paint today ?…

– increasing scientific knowledge
– new pigments
– new technology
– new theories

It is an adventure. It is research conducted by the painter using colour in order to obtain a melody, something poetic, in a sense, something approaching what one can experience at the sight of a rainbow.

It is the creation of a luminous & vibrant coloured structure to access what is immaterial by way of the virtual.

Science reveals a portion of the world of Colour, from which art can underline & magnify its spirit. 3 Phases:

1. *Exploration of a luminous spectrum*
   The simultaneous contrast in colours & residual images,
   boundaries of colour & vibration.
2. *The psi-colour*
   Based on psychometrics, the psi-colour is a coherent ensemble of mobile colours.
   Vision, touch, physical manipulation – it takes the form of a very real educational tool.
3. *The rose of colours*
   Colour & space
   Appearance of multiple dimensions
   Emanation of principal forces
   Spectral analysis of each hue in order to obtain a homogeneous vibratory field.

## Conclusion

In her will to connect the immaterial to the material, the painter goes as far as to harness the very colours of the rainbow. In so doing, he may savour them to infinity – both mentally & physically.

# A study on consumer preference to different styles (patterns) and color collocations

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## Abstract

This research topic focuses on how consumers' preference and purchase behavior will respond to different pattern styles and colors combinations in products design, utilizing the digital inkjet printing technology. This research use digital printing technology to prepare twelve pictures and/or patters, all in different styles and colors combination, in order to analyze how customers will favor each one of the different combinations. Based on the twelve pictures, we will explore what the interviewee's preference are in patterns and colors combinations, subject to other parameters such as ages and incomes, and how that affect their willingness to purchase. The characteristics of the twelve picture and/or patters are listed as below:

| Topic | Style | Color | Representativeness | Cognition | Effect | Picture No. |
|---|---|---|---|---|---|---|
| 1 | inheritance | low saturation | realistic | Static | soft | 8 |
| 2 | classic, traditional | warm color | realistic | dynamic | soft | 1、2、3 |
| 3 | elaborate, oriental | high saturation | realistic | static | strong | 4、5 |
| 4 | landscape, natural, | cold color | realistic | dynamic | soft | 9、10、11 |
| 5 | modern, architectural, | dull color | realistic | static | soft | 6 |
| 6 | free, linear | bright | abstract | dynamic | strong | 7、12 |

This questionnaire was based on the above twelve pictures, seeking to find preferred colors and pictures and/or patterns combination among interviewees. The results show that interviewees in older age, higher monthly income, and greater monthly disposable income, have a distinct preference in images of classic and modern designs, and in bright, cool/warm color. In addition, these interviewees signify their preference of silky, soft and smooth hand-felt material. The analysis also indicates that interviewees' styles preferences were quite differently while minor or not significant difference to the colors of the twelve pictures. That is to say that color composition of pictures doesn't impact interviewees' preference to the pictures while the style of the picture does. The findings of this research concerning consumers' response to product designs of styles and colors, as well as different material hand-felt, represent significant information and insights about the future of new product development, with regard to the application of innovative digital inkjet printing technology.

# Works of light in space

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## Abstract

For many years I have been experimenting systems which make natural light and artificial lights combine so as to create visual installations. Some works are based on properties of our perception, such as the phenomena of colored shadows. The particularities of some materials such as transparency or reflection have also guided me in my choices. I often include in these works some form of dynamic. These creations are subjected to a sort of 'staging' of the places or architectural constructions.  The drama is born from social life, the passerby is most importantly an inhabitant, a citizen.

The exterior of many buildings built since the Second World War is often characterized by heterogeneity of the materials used, which sometimes leads to a visual chaos. This chaos often found itself in the architecture of the countries that deploy in recent years a great energy to build new or rehabilitate old city. To maintain visual coherence, the perpetrators of these operations involve, among other things, color designers, but limits their shares are reduced. Technological development has enabled the creation of large openings. Today the windows are an important part of many buildings. Besides the effect on the external coloring of the buildings, the level of illumination inside was often changed considerably. These transformations are not considered carefully enough. Often these problems are discussed in terms of functionality or treated too strictly. More use of visual artists is expected to address these problems by considering more expressive sites. It is within these two approaches that I approach these environmental issues.

What size site is important or not, its theatricality screenplay is the source of a work environment. I worked at very different scales. In China, for example, and the coloring of a city in France, among other sites, to produce a light installation in a chapel. In both cases the narrative elements consist of cultural history, local life, the evolution of techniques and attitudes, have been the source of ideas. To illustrate my point, I have six projects: 1 - The coloring of the city of Tanggu, owner planning departments of the city of Tanggu, China, 2008. 2 – 'thoughtful gestures,' work for the stadium in the city of Jianyin, China, 2010. 3 – 'The Colour Out of Space,' a light work for the Baroque chapel of Apt in Provence, France, 2000. 4 – 'The blue flowers in meadow,' a light work, outdoor, in the Centre region, France, 2002. 5 – 'The colors of the spirit,' a light work for the Parliament of Saxony-Anhalt, Magdeburg, Germany, 2003. 6 – 'Signal,' light work for Carrefour, Créteil, France, 1968.

# Lumalert: Safety signal system for cyclist

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## Abstract

Inspired by the actual conditions of cyclist and public cycle-ways in Bogota, Colombia, LumAlert aims to reduce the number of traffic accidents by providing the cyclists under low-light conditions, a signaling system that would turn them into more aware drivers.

A detailed observation of the cyclist in his context was needed in order to identify that: 1) One of the easiest and most efficient ways for cyclist to communicate with other drivers and pedestrians on the road is through hand signals and 2) In order to capture the cyclist hand signals under low-light conditions, a device that interprets and transforms the hand movement into a visual element (light effects combined with warning colors) should be placed strategically and worn by the cyclist at anytime.

These two mayor statements were the starting point of the system design process, which involved electronic device prototypes and arduous experimentation with the user in his immediate context. The result obtained is a safety signal system that interacts with the cyclist by interpreting gestural motions (input) to activate LED source colors (output) and therefore emit a visible signal to communicate behavior to both pedestrians and drivers on the road (left and right turns, slow down or stop).

Three different modes of operation, corresponding to three positions in a range of 90" and three colors, are given: 1) Yellow flashing when the cyclist extends his arm to indicate right turn or left; 2) Red when the cyclist wants to slow down or stop; 3) White, as red light, remains on to follow traffic security standards.

The employment of visual warning colors, like red and yellow, combined with flashing lights effects are easily detected by the eye of the driver, therefore the perception of hand signals in low-light conditions are increased by this system where the combination of light and color becomes a way of communication in a hostile environment where being visible can be life saving.

# A digital visualization tool for the evaluation of colour vision deficiency

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## Abstract

In the advance and widely spread of new-style display and illumination technologies age, such as wide colour gamut displays and colour-varied LEDs, we think that more problems of colour discrimination would occur often than the past. However, if the people with colour vision deficiency (CVD) could be efficiently diagnosed by a digital tool, it would help us to build a friendly visional environment of living and working for considering both normal colour vision and CVD observers. A digital tool named Digital Visualization Tool (DVT) was developed in this study.

The proposed colour vision test plate based on DVT has three parts of process. Firstly, we must decide the content (symbol or number) in the DVT system. Secondly, we have to set the appropriate parameters (type, density and colour) for designing a new test target. Finally, we decide the text colour and the background colour based on the principle of confusion lines. There were two experiments designed in this study. The first experiment was that all of test plates would be checked on a sRGB-calibrated monitor embedded with CVD simulating software. The observers participating in the psychophysical experiment would include 8 young people with 4 normal colour visions and 4 CVDs. The second experiment was that the CVD participators are required to compare the newly developed pseudoisochromatic plates before and after simulation, which were also displayed on a sRGB-calibrated monitor. Five levels of scores were designed from 5 point (easily discriminable) to 1 point (difficultily discriminable) when the DVT's performances were evaluated.

The result evaluated by CVD observers shows that the performance of the proposed DVT is rather consistent with the conventional methods (i.e. Ishihara plate and Dichotomous D-15 Test). It demonstrated that the DVT can be well used for checking colour vision. The proposed DVT can be adaptability adjusted in designing text content and colours on colour vision test plate. In addition, it can easily reproduce the exact colours on a well colour-calibrated monitor.

# Capturing the gist of color information in an image

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## Abstract

The aim of this study is to evaluate how well one can describe our general impression of the colors in a complex image with minimal number of parameters.

A total of 120 photos were sampled as the test materials of this study. To capture the gist of the color information in an image, we computed seven parameters, namely, brightness, contrast, saturation, the amount of red, the amount of yellow, the amount of green, and the amount of blue, in an image. The color of each pixel of the image was converted to HSV format. The brightness and saturation values are the average densities of V and S across the image. The contrast value was a form of Michelson contrast weighted non-linearly by the ratio of the size of bright area to that of the dark area. Each of the amount of the four basic colors was derived by centering an integration window, a rectified sinusoidal function in this case, around a given unique hue, the span of the integration window was adjusted to match to the range of hues that carries the tint of the center unique color, then all the weighted H values under this window function were integrated.

Ten observers were recruited to report their impressions about the general color compositions of the test photos. They were also instructed to rate the overall brightness, contrast, and the amount of the four basic colors of these images.

A detailed content analysis of the free reports on the color impression reveals that the participants did describe their impressions on the dimensions of brightness, contrast, vividness, and hues. However, few participants decompose their hue descriptions into the exact four basic opponent colors. More often they use the dimension "cool vs. warm" instead. Some color terms such as "brownish" and "pinkish" were not of the four basic colors, either. Given these exceptions, the great majority of reported dimensions can still be approximated by combinations of the seven parameters computed in this study.

The scatter plots plotting the values of computed parameters against human ratings show very good linear relationships except for the parameter of contrast. More efforts should be put in to find a sensible and sensitive index to the subjective contrast of an image.

In summary, we proposed and tested the idea of using sparse codes to specify the subjective color impressions of complex scenes. The results show that while the seven parameters predict the rating data quite well, some dimensions revealed by the free report are not captured by the basic parameters. More higher order parameters need to be sought after to enhance the performance of the coding.

# Image-dependent colour palette applying to preferred colour correction of flat panel displays

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## Abstract

Colour quality is an important issue for display manufacturers. Visual assessment and physical colour measurement methods have been widely used for evaluating colour quality of flat panel displays. In this study, image-dependent palette was constructed based on memory colours such as skin colour, green grass and blue sky. Software was provided to automatically measure colour palettes and to accurately correct colour in a short time period.

# A new saturation model

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## Abstract

Colour appearance has been defined by CIE colorimetric system in terms of a three dimensional space with variables such as lightness, colourfulness (or chroma, chromaticness) and hue. However, scaling the dimension of colourfulness can be properly performed only by observers with a sufficient understanding of a colour appearance. Even if the observers are well-trained prior to the experiment, the visual results for scaling of colourfulness may still show poorer data consistency as compared with the other two dimensions. To address the issue, the present study was aimed to develop a new "saturation" model that better reflects novice observers' view of colour appearance. The "saturation" scale has been identified from the authors' previous unpublished study as a dimension orthogonal to both lightness and hue.

A psychophysical experiment for the scaling of saturation was carried out using category scaling method. A panel of 29 British observers (=14 male and 15 female, participated in the experiment). All observers had normal colour vision, with no colour science training and were naïve to colour appearance scaling.

Forty-eight 3 x 3 inch colour patches were used as the stimuli from which 24 randomly selected were replicated for repeatability test. All colour samples were selected from the Natural Colour System (NCS) to cover a wide range of hue, chromaticness and blackness. Observers were asked to assess each colour in terms of "saturated/unsaturated" on a six point scale. Each colour was presented in a VeriVide viewing cabinet with a grey background (X=154.05, Y=159.40, Z=188.15) illuminated by a D65 simulator, situated in a darkened room. The reference white in the viewing cabinet measured X=491.95, Y=511.35, Z=557.20. The viewing distance was about 60 cm.

The existing CIELUV saturation was tested using the experimental data for the "saturated/unsaturated" scale. The correlation coefficient between the observer response and CIELUV saturation was 0.69. A new saturation model was developed based on CIELAB using a modified colour difference formulae, with a high correlation coefficient of 0.90. This model may serve as an alternative to the third dimension of colour appearance that better reflects novice observers' view of colour appearance.

# Inter-agreement between typical colour measuring instruments

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## Abstract

Colour measurement instrument is widely used for colour quality control for the surface colour industries such as graphic art, textile, coating. This study is aimed to evaluate the inter-instrumental agreement between some state-of-the-art colour measuring instruments including a digital camera system and four spectrophotometers. The spectrophotometers were divided into two groups (d:8° and 45°:0°) according to the illumination and viewing geometry. Comparisons were made between the instruments having the same geometry. The accuracy of each instrument was investigated against the results of NPL-CERAM standard provided by the CERAM. Ten paint pairs supplied by DuPont were used to test instrumental performance using colour-difference between instruments. The results showed that the accuracy performance (using CERAM tiles as standard) was worse than the inter-instrument agreement. The measure using relative colour-difference gave the best performance. It was found that the d:8° spectrophotometers performed better than the 45°:0° spectrophotometers. This is mainly due to the use of double colour analysers for the former. The camera based system was also evaluated. Although its performance was affected by the daylight lamps used with some variation, it is still effective for measuring colour-difference between a pair of samples.

# A cross-cultural study of the relationships between colours and products

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## Abstract

The purpose of this study is to investigate the salient impact of the colour attribute for both high- and low-involvement products. According to our literature review, little attention has been devoted to both low- and high-involvement products from a cross-cultural perspective. In order to gain a better and deeper understanding of how colour and product types may affect consumer perceptions in different cultural contexts, three apparel products that include socks, t-shirts and eveningwear (women's dresses/men's suits) were deliberately chosen for this study. A self-administered questionnaire was employed to collect demographic data, to measure and understand consumer colour perceptions in Canada (Western society) and India (Eastern society). Young female subjects were solicited and a total of 132 and 88 useable questionnaires were collected from Canada and India respectively. According to the findings of consumers' perception of colour, Canadian respondents were relatively more concerned about their personal experience and self-contentment than the Indian counterparts. In addition, it is evident that the colour cue played a relatively less significant role as compared to fit or comfort and style. Thus, it is reasonable to suggest that colour cue becomes less important when other product cues are available.

# Colour and light in urban planning: Policy, palettes and the sense of place, mood and movement

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## Abstract

The Atelier Cler defines and develops chromatic studies as a special method or procedure in understanding and approaching *light-texture-colour* in urban space, industrial and rural environments. This paper deals with some significant findings and tools associated with creating sense of place, mood and movement including aspects of light, texture and colour related to colour concepts for urban planning. This paper aims at discussing the role of (natural) light in conceiving colour palettes for urban planning and how light and the textures of materials have an impact on the perception of colour appearance. It is important to note that the notion of *light-texture-colour* has considerably evolved over time. Since the 1970s the Atelier Cler has been realising colour concepts for valleys, villages, industrial parks, newly developing areas, etc. that are in harmony with the natural surrounds. The Atelier's approach aims at emphasising a dynamic equilibrium of the features of existing and newly introduced colours.

Historically three major stages of *light-texture-colour* can be distinguished:

1. During the 1970s and 1980s research on *light-texture-colour* focused on qualities of light – both of daylight and related to seasonal changes – and their interaction with space-defining elements of *colour appearances*, e.g., aspects of mineral formations, vegetation, water and sky.
2. During the 1990s, newly introduced metallic opalescent materials generated a fluctuating appearance of architecture façades whereby light interacts with coloured surfaces.
3. To date new materials with optical properties, e.g., pearl and iridescent qualities, not only increase effects of light but also create a broad palette of different colours. The effects can only be perceived by the viewer in motion. In this sense movement has become an essential element structuring the chromatic perception of the built environment.

## References

Cler, M., F. Cler and V. M. Schindler. 2005. Chromatictownscape: A manifesto. Colour communication and cultural identity in urban planning and architecture. In *AIC Color 2005. Proceedings*, edited by J. L. Nieves and J. Hernández-Andrés, 2 vols., Granada, 405-408.

—. 2007. Colour as a Communication Device in Urbanism and Architecture: A Case Study of the New Town of La Croix- Bonnet, Bois d'Arcy, France. In *AIC 2007 Color Science for Industry. Proceedings*, edited by Guanrong Ye and Haisong Xu, Hangzhou: Zhejiang University, 219-222.

—. 2008. Chromatic Urbanscape: How specific geographical sites affect colour and how colour has an effect on landscape, the urban fabric and architecture. In *AIC 2008 Colour – Effects and Affects. Proceedings*, edited by Iman Kortbawi, Berit Bergström and Karin Fridell Anter, Stockholm. Paper No. 134.

# A promenade through Buenos Aires – colour and art changing the imagined city

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## Abstract

Grey is the imagined colour of Buenos Aires, according to the studies undertaken by Monica Lacarrieu (2007), with just one exception, the emblematic La Boca. Nevertheless, recent intervention projects are bringing new colour to the city, even if it is not yet noticed and incorporated into the mental image of the citizens.

This paper starts with a stroll through some intervention projects, to feel their presence in the dynamic of the city as the light changes from sunrise to nightfall. We pass by, La Vereda, that brought together local children, teachers and artists in common cause to repaint the neighbourhood with their project "Pintar el Once" (2006). Then we reach the commercial and touristic area of Abasto where we find two other projects: "El Abasto y el fileteado porteño" (2004), where the strong colours and traditional drawings of fileteado are present in some facades around the Carlos Gardel Museum; and "Musical Scores" (2002), an artistic intervention by Marino Santa Maria, comprising eight large-scale pop portraits of Carlos Gardel painted on some of the buildings. Later we can appreciate the effect of light in the mosaics of "Calle Lanin" (2001-2011), another art work by Marino Santa Maria and alternatively, in the same district of Barracas, we can see how the calm residential area has recently been transformed by the design participation project "Barracas Pinta Bien" (2010), from the Civil Association Más Color. By doing so, and after a thorough study of the existing literature on the subject, along with opened interviews conducted by this author with actors, professionals (designers, architects, artists), and inhabitants of these places, we can better understand the interventions described in the case studies. We pay attention to the processes involved in these projects and how do they help us understand further the common areas between art, architecture, design and urbanism. Even though there is no clear urban planning by the Municipal Government in Buenos Aires the city is a work in progress of individual and collective interventions. The use of colour in the examples above appears to be accepted as a legitimate way of building the public space, as an interesting result of a public participation process, and an expression of its citizens. These interventions produce new visual references, and generate singularities in the city image. Even if they seem to be a drop in the ocean, the changes are afoot. Perhaps in the future the citizens of Buenos Aires will reimagine their self-identity as the dwellers not of a grey city, but of one of more vibrant colours.

# Some inputs for colour design education: An empirical study correlating variables gender, area of interest and colour blindness

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## Abstract

The purpose of this paper is to present an empirical study done so as to test how some known colour design studies relate to Model Sens|Org|Int, in order to detect from these studies which ones may be generalized to human beings with normal eyesight. Sens|Org|Int Model was devised by the present author, published and awarded in IVLA's (International Visual Literacy Association) 2007 *Book of Selected Readings*. The model differentiates the three processes that occur in human perception: sensory impressions (Sens), organizing processes (Org), and interpretive processes (Int) of visual perception. This model unites synthetic and the analytical approaches to psychology as well as physiological inputs from the visual neurosciences (Chalupa & Werner 2004; Kaiser & Boynton, 1996; Knoblauch & Shevell 2004; Pinna & Spillman 2001; Shimojo, Kamitani & Nishida 2001; Spillman & Levine 1971; Zeki 2000) on how the brain works, and relates them to classical art and design principles.

The starting point of this research was a bibliographical review of colour design studies, so as to map them in terms of Sens, Org and Int variables. Since the main objective here was to detect colour studies that tend to be valid for all human beings with normal eyesight, emphasis was given to Sens and Org variables. Sources for this bibliographical review included Albers (1974), Chevreul (1854/1987). Itten (1979), Beck (1972), Birren (1978, 1986), Evans (1948), Gerritsen (1976), Graves (1951), Hickethier (1973), Kuppers (1975), Pedrosa (1995); Sausmarez (1974) and Wong (1997).

The empirical study was conducted using a questionnaire with eighteen questions elaborated from the bibliographical study. This questionnaire was developed in order to evaluate the subjects' perception related to Sens and Org variables. This questionnaire was applied to 300 subjects, classified into different categories: age, gender, colour blindness and professional area. Altogether, the subjects tested were undergraduate students in Fine Arts, Design, Business Management, International Relations, Communications, Product, Mechanical and Electronic Engineering. From the 300 subjects tested, 57% were male and 42% female.

Analysis of these questionnaires comparing the subjects' categories offers inputs for the main conclusion that the processes tested and their visual communicational possibilities are independent of gender or professional area. Thus, the colour design studies tested may be considered as Sens and Org processes of perception, and thus, tend to be generalized to all human beings with normal eyesight. Therefore, colour educators may consider these inputs when attempting to teach objective colour design principles.

# Monocromatism and the architecture of industrial landscapes

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## Abstract

For the last couple of years, the CO3 research project has focused on the possibilities of establishing new links between cromatism and contemporary architecture. In this line, several projects on architectonical intervention have been developed particularly taking into account colour and its composition laws. These proposals for the future, which can be viewed on www.superposiciones.com have called chromatic noun:  interventions re-arranged a chromatic sequence above, changing the landscape and its perception.

When a colour range – indeed related to perceptual experiences – mixes with acromatic colours, it loses saturation to the extent that it can be even mistaken for monocromatism and absence of colour. In the evolutionary process of monocromatism, the attempt to replace colour-matter by the energy of colour-light appears as an essential step in the arts in the twentieth century. The possibilities of architectonical perception are maximized by giving both the surrounding environment, as well as the spectator, an active role in the creative process. Monocromatism, initially related to the expression of atemporality and autonomy, eventually becomes the basis of the temporal change of human gaze.

We understand the architecture of industrial landscapes as a dialectical game of oppositions, representing both the permanent tension between fullness and vacuum; between heavy machinery and thick walls, and light and mobile industrial mechanisms. It moreover represents an opposition between time and change. The possibility of considering industrial architecture focusing on the concept of "ruin" associated to it is built upon an interest in minimally intervening in those industrial settings by inserting a sole essential form that, in its turn, becomes the backbone of the existing spatial forces with the view to turning the perception of material remains into mental spaces.

This type of architecture helps us to discover different form of intervention that could make possible to establish an architectural evolutionary line, paying attention to chromatic characters, and corroborating that colour is an architectural intrinsic factor with the property of change spaces and make it different. Through these punctual interventions, the characters of industrial buildings take a new sense, a new image, without lost their identity, and obtaining in many cases, a new use which can boost their value.

# A holistic view of colour – a bridge between physics and metaphysics

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## Abstract

My artistic experiences accompanied by intercultural studies on the function of colours are the basis of my work. Thus I do not represent a specific academic position. In my presentation I'd like to give an insight into the metaphysical level of colour including the Sirius colour system.

As physics, metaphysics is concerned with the laws of nature and the origin of light. But metaphysics has split off from the scientific approach, which emphasizes matter over mind. It is of central importance for our present time, to connect the material sciences and metaphysics, to facilitate a new holistic view, and the so desperately needed new consciousness. What Eastern civilizations have known for thousands of years is today confirmed by our Western science: everything is energy! We are surrounded by a bioelectrical field, through which an information exchange takes place. Constantly we are in communication and interaction with everything.

Light is the mother of colours. From the unity of light the colours unfold in their diversity. This so-called 'visible spectrum' is a small one compared to the entire spectrum of rays. Each colour frequency has specific information – therefore colours are waves of energy transmitting information. Colours form a system of human orientation. Through colour we interact with nature. Colours generate a vibrational field that permeates and alters each living organism. Biophotonic researchers have been able to show that every living cell produces minimal but measurable light quants, so-called biophotons. They form the bridge over which all life is connected to the cosmic stellar light. This implies that the human being is a light system which can be regulated through colour. Each specific colour frequency affects us, whether we are conscious of it or not. It influences all dimensions of the body: the physical, the mental, the emotional and the spiritual. Here then the law of resonance is at work. Although the effect of colour has been recognized in ancient times, the function of colour as a mentor for the spiritual growth of humankind is in its comprehensive meaning yet hardly recognized.

In 1995 I started to research and develop an expanded and holistic colour system based on five primary colours. Due to their purity and balanced frequencies they allow a precise mixing of an unlimited range of harmonious and differentiated nuances.

Differentiated nuances promote differentiated perception. The new paint material I produced which I named 'Sirius Primary System', demonstrates that every material colour inherits the metaphysical dimension of its cosmic origin.

# Image retrieval by impression word based on feeling prediction from color combination

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## Abstract

This paper presents a new image retrieval method by impression words, which are related to color feelings of images. It is difficult to find images that have required feelings, such as, a pleasant scenery image, a calm scenery image. For such image retrieval, we must add an appropriate impression word to each image as a keyword before searching. If we add impression words to all of the images in database manually one by one, it will be time-consuming and, moreover, the end results will depend strongly on the person's skill who adds the keyword. To solve these problems, we proposed the method to relate images with the impression words automatically based on feeling prediction from color pixel information of images.

The proposed method relates four feeling values to each image in database. The feelings are pleasantness, contrast, floridness, and warmth. The feelings are predicted from three color combinations in the image by feeling prediction formulas. These formulas were proposed by Nayatani and Sakai. The color combination is detected from the image by color image processing. First, the image is divided to 16 areas. Then, the representing RGB color of each area is detected by color histogram analysis. The detected 16 colors are clustered to three colors by using the k-mean algorithm. These RGB colors are converted to Munsell hue, value, and chroma (HVC) values. Feeling coefficients for image are calculated from these HVC colors by the feeling prediction formulas.

The method also relates impression word and the feeling values. The usage of impression word would be a little different between users. Therefore, the relationship between impression word and feeling values is determined for each user by questionnaires. In questionnaires, users selected several impression words for a displayed image from an impression word group. Average feeling values of images that are selected to an impression are defined as the feeling values of the impression. Images are retrieved by feeling value matching of images for an impression keyword.

We examined image retrieval tests for evaluating the proposed method. We investigated feelings of images in database by questionnaire for 10 subjects. They select several impression words from 38 Japanese impression words for each image in 100-image database. These impression words mean fresh, nostalgic, passionate, calm and so on. Some words were not selected in the questionnaire for each subject. Then, image retrieval tests by impression words from other 200-image database were done. The retrieved image group for each impression word was different between subjects. Most of these retrieved image groups included images appropriate for feelings of subjects.

# Using 2D image composition to model and evaluate soldier camouflage in the visible wavelengths

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## Abstract

Development and evaluation of camouflage systems is usually very expensive and time- consuming. Any evaluations that could be done using simulation prior to a field deployment would significantly shorten the development cycle. A typical simulation scenario would for example evaluate the effectiveness of a new concept soldier camouflage pattern within South African bush environment.

For the sake of simplicity the decision was made to use a 2D image composition approach, rather than developing a full 3D synthetic environment. A simulator, using the MATLAB scripting language, has therefore been developed to automate the 2D image composition and colour matching tasks.

The simulation method includes a background measurement process, a background and digital camouflage pattern calibration process and a 2D composition process. The background measurement involves taking a photograph of a scene with a mannequin in a grey uniform. For calibration purposes a standard colour reference (GretagMacBeth ColorChecker) is included in the background scene. The CIELAB values of each colour in the digital camouflage pattern and the L* value of the grey uniform must also be measured from test prints. The grey uniform's pixel brightness in a white balanced background image is then used to modulate the digital camouflage pattern without requiring any further colour correction or calibration steps. A heuristic was developed to automatically isolate the grey uniform from the background.

The current camouflage model is however still a simplistic one. The material printing and camera image transfer functions have for example not yet been included in the model. The material is also currently modelled as having a perfectly diffuse BRDF and the scene illumination is assumed to be isotropic (i.e. identical upwelling and downwelling spectral distributions). We plan to address these simplifications in the near future.

# Towards an automated method of objective gingival inflammation assessment on colored digital still images

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## Abstract

Gingival health state assessment is a research field with a long history in the area of dentistry. Early methods assessed and classified gingival health subjectively as good, medium or poor. Later methods used indices that quantified several clinical signs such as the location of inflammation, the area of affected gingivae or gingival encroachment over tooth surface. However, the limitation of most indices is the subjectivity of the observer. In contrast, the goal of our work is to establish methods for objective quantification of gingival health state assessment. By this token, our work aims on establishing a novel method for image acquisition of colored oral cavity digital still images and on developing robust and reliable methods for automated quantification of objective gingival inflammation assessment.

We present a novel method for image acquisition, which requires only standard photographic equipment (single lens reflex camera, camera tripod, circular polarization filters) and can be accomplished in non-laboratory environments to maintain applicability of use at dental practices. So acquired images are white balanced to allow comparison of color features amongst several images of the same subject. This qualifies our method to be utilized for long-term studies on individual subjects health states. Following our acquisition approach, we obtained an initial image database of 90 images from 27 subjects with healthy gingivae.

To objectively assess the gingival health state of a subject, we intend to quantify redness and gingival encroachment as parameters for gingival inflammation assessment. We used images from our database to apply various image analysis techniques, amongst which are *K-means*, a *nearest neighbor* and a *Self Organizing Map* approach to segment regions of interest in the images. For the case of teeth region segmentation, the best results were obtained with the *Self Organizing Map* algorithm and *CIE-L\**, *a\** and *b\** components of the images as feature vectors. We also found the selection of color space being strongly related to the performance of segmentation.

Summed up, our results show that usage of an automated digital image processing streamline has a huge potential for objective identification and analysis of gingival health state in routine clinical procedures.

# Gaussian-metamer-based prediction of colour stimulus change under illuminant change

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## Abstract

Predicting how the LMS cone response to light reflected from a surface changes with changing lighting conditions is a long-standing and important problem. It arises in white balancing digital imagery, and when re-rendering printed material for viewing under a second illuminant (e.g., changing from D65 to D50). Von Kries scaling is perhaps the most common approach to predicting what LMS cone response will arise under a second illuminant given the LMS under a first illuminant. We approach this prediction problem, instead, from the perspective of Logvinenko's new colour atlas, which is based on idealized reflectances called rectangular metamers that are specified by 3 parameters, A (chromatic amplitude), D (spectral bandwidth) and L (central wavelength). Logvinenko's coordinates can be used for predicting illuminant-induced colour stimulus changes as follows. First, the observed LMS under the first illuminant is converted to Logvinenko's ADL coordinates. Second, the reflectance spectrum defined by the corresponding ADL coordinates is calculated. Third the resulting spectrum is mathematically 'relit' using the second illuminant to predict the new LMS under it.

An advantage of predicting illuminant-induced changes to cone response in this way is that it is based on relighting a member of the metamer set of the input colour stimulus. As such, the prediction will be plausible in the sense that it is based on a reflectance that is indistinguishable from given reflectance under the first light. As Logvinenko points out, for the von Kries method, there is no such guarantee; so that, at least in principle, the von Kries error can be arbitrarily large. In practice, however, using rectangular metamers for the prediction does not always produce the best results on average, perhaps due to the sharp edges in the rectangular functions. Logvinenko has also proposed a Gaussian parameterization of his colour atlas. Since the Gaussians are smooth by definition, we experiment with them as a vehicle for predicting the effect of illuminant change. The first step is to calculate the parameters of the Gaussian-metamer coordinates (KSM), which is analogous to computing the ADL coordinates of rectangular metamers.

To compare the performance of the KSM and von Kries methods of color stimulus prediction, we synthesize the LMS tristimulus values of 1600 Munsell chips under one illuminant (e.g., D65) using the Stockman-Sharpe cone fundamentals, and then predict the LMS values under the second illuminant (e.g., D50) using both KSM coordinates and von Kries scaling. These predictions are compared to the computed ground-truth LMS values for the second illuminant. The Gaussian parameterization of Logvinenko's colour atlas on average predicts the change in LMS resulting from a change of illumination better than does von Kries scaling.

# Colour contrast revisit

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## Abstract

Simultaneous colour contrast is a phenomenon that a colour appearance changes with the change of its surrounding colours and has been studied traditionally using a 3-field paradigm consisted of a test colour, an induction field, and a background. Since the primarily application of this study on colour contrast is to perform content-based image retrieval to a collection of wallpaper images that have variety of patterns overlaying on various coloured backgrounds, extensive investigation has thus been carried out in this study on coloured background contrast, i.e., a 2-field pattern without any induction field. The experimental setting is similar to a typical wallpaper image where an object of interest is surrounded by many other non-uniform colourful objects. Twelve psycho-physical experiments have then been conducted with four background colour, including grey, red, green, and blue. Each background colour comprises three luminance levels with CIELAB L* being 30%, 50% and 70% respectively. Thirty test colours are utilised in the experiment and are estimated by a group of 10 subjects using an approach of magnitude estimation.

In general, the effect of a 2-field paradigm is different from that of a 3-field pattern. For lightness, darker background does make colours appearing lighter, which is in line with the findings with the literature. However, the amount of the shift in this study appears not significant with CV values ranging from 11 to 17 when comparing with the variations within subjects that CV values amounting from 17 to 22. The reason could be due to the fact that the reference white being at the same background with a test colour. In this way, a coloured background opts to contribute equally in terms of lightness to both reference white and test colours.

By contrast, changed backgrounds tend to vary perceived colourfulness considerably. Similar to reference white, the reference colourfulness is displayed on the same background with a test colour. However, the estimation of colourfulness appears to be effected largely by the change of lightness levels of a background. In other words, a darker background makes colours appearing more colourful, especially for red background where colours appear more colourful when the difference of luminance levels between two backgrounds increases. For green and blue backgrounds, on the other hand, the perceived colourfulness tends to be more colourful than under grey background regardless luminance levels.

CIECAM02 has been evaluated to predict the effect and has shown potentials in doing so. So far, much of our success owes to our limited data, further investigation is worth doing to further the modification and evaluation, especially in the need to define the constant factor value of $\lambda$, the factor for chromatic adaptation response, in the formula of CIECAM02.

# Colour and light in the media architecture envelope: Kinetic and luminous effects on building façade

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## Abstract

In the contemporary architectural project, the building of media facades is growing up. In the collective imagination these systems refer only to an architectural skin made by electronic tools: large bright screens, video walls and architectural projection systems, very different from each other, but still always of luminous and informative type. So you think almost exclusively to a massive use of light to adjust the visibility and the perceptiveness of the architecture. To do this, the planners use the more advanced materials and systems that induce a sense of dynamism to the vision. Recently they use fiber optics, OLED and Neuroled. In reality a media facade can change its image and, at the same time, its form not only perceptually with the aid of digital artificial instruments or with the now usual colored coatings, but also with a "simple" movement of its components. These are panels and mechanisms more or less dependent on each other and with the building, poly or monochromatic, transparent or opaque, metallic or plastic etc. Their movement can be created with purely kinetic systems (automatisms), hydraulic systems or pneumatic. An example of this technical solution is "Daisy World" experimental project by Thomas Nicolai, that uses a pneumatic mechanical system for handling colored rubber components (or similar material) in the form of a daisy. In other cases they may be components whose movement is generated from natural sources such as wind or sunlight, as in the works of Ned Kahn. The research made by the author inside the Color and Light Research Unit at Iuav University of Venice, shows that the realized media facades and the facades in developing, can be classified according to the systems used to achieve them. The identified categories are: luminous facades, mechanical facades, liquid facades, facade's projections. Because of the vastness of the topic and of the current research, in this paper it will be delimitate the field of investigation to the mechanical media facades. The aim of this paper is to catalogue and classify the mechanical media systems for architectural façade, used or potentially usable for architectural media envelopes. The envelopes tested were made either on existing buildings and on new construction. The research was conducted through a careful analysis of the state of the art, a literature survey and a cataloguing of 100 case-history. Each project was analyzed by classifying the architectural envelope in envelope-typologies (applicated and integrated), identifying the types of interfaces, technologies and materials used to make it happen. The result of this contribution is to investigate three fundamentals topics:

1. the type of technologies and building systems are currently in use for the construction of mechanical facades (kinetic, pneumatic and hydraulic systems);
2. how those media-system could influence the perception of color and light on the contemporary architectural surfaces;
3. their interaction with the surrounding urban space. In this analysis they will be included natural and artificial parameters and systems.

# Safety Yellow: Studies on the spatial effect of colour demonstrated on the example of Ulmbergtunnel in Zurich

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## Abstract

'Safety Yellow' is an attempt to explore the rules of spatial perception and the relationship between spatial form and human behaviour, in a psychologic or physiological sense. The focus is on the relationship between colour, light and spatial form.

The Ulmbergtunnel is a 260 metre long passage for pedestrians and cyclists between two districts. For both it is an insecure place as they share an only 3.5 metre wide track for both directions. Due to its inhospitality the passage constitutes an unacceptable space especially for pedestrians: It is difficult to appraise distances or to locate the own position. The monotony of the space enhances the impression of the tunnel so that the isolation from the outside world turns into a negative experience.

Can the introduction of colour change the perception of the tunnel in such a way that the connecting passage way, currently a non space, becomes an independent space with its own character that offers passers-by better orientation and thus a subjective feeling of security?

Studies on the spatial effect of colour analyse the relationship between colour, light and spatial form. Which surfaces define the spaces and how do they influence their perception? How do tunnel and colour space relate to each other? Can colour manipulate the space so that the lacking relationship with the outside world is compensated? How to achieve the impression of natural light, creating the illusion that the underground space opens itself to the outside world?

The dominant topic of the tunnel as a transitory space is chosen as the central theme for the new colour design. When crossing the tunnel the following dynamics occur: The yellow centre line develops into a three-dimensional form, which as a space within a space marks the centre of the tunnel before dissolving in its second part. The colour intervention gives the crossing of the tunnel its own rhythm. The friendly shades of yellow lighten up the dismal locality and are associated with light establishing a connection to the outside world. The accentuated movement and the focus onto the center of the tunnel facilitate a better orientation in the underground. The feeling of insecurity disappears.

The intervention enhances the tunnel, transforming it from a non-space connec-ting localities into an independent locality with its own characteristics. The dramaturgy of the colour created by the sequence of increasingly light tones turns the unpleasant tunnel into a positive experience for the passers-by who are attracted by the light. The pedestrians and cyclists participate in an experience which renders their perceptual capacity anew.

# The difference of color preference between color patches and products

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## Abstract

The aims of this study are (1) to compare the order of color preference between color patches and colored mugs and (2) to see the difference between the preferred colors and the chosen mug as gift. In order to fulfill these purposes, this study planed two experiments. Eighty observers took part in the experiments, including 50 observers in Experiment I and 30 observers in Experiment II, respectively. The average age was 22.3 years old. Each observer was required to arrange color patches and mug colors in order of color preference. After finishing the order task, each observer was allowed to pick one of the mugs as his/her gift. The color samples used in the experiments were selected from 11 basic color terms (red, orange, yellow, green, blue, brown, purple, pink, white, black and gray colors). Note, there are no purple and gray colors on mugs. To understand the context of color preference, each observer was interviewed after the experiments. The results obtained from the order tasks showed that the order of color patches and mug colors are consistent. The correlation coefficient is 0.87. However, it was found that the most preferred mug color was not selected as the gift. The interview results showed that for selecting an owned mug, the observers not only considered the color preference, but also the shape of mug. The other factors included personal affinity, drink-related and usage situation and appearance attributes.

# The use of fundamental color stimulus and artificial neural network to enhance the performance of Color Profile Management Systems

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## Abstract

A popular standard color management system for controlling color reproductions is the ICC color profile. RGB printers based on the ICC color profile rely on a look up table (LUT) in which the input data could be RGB and the output data could be Lab or vice versa. In a profile making process, certain known RGB values encompassing a large gamut are printed and then their respective reflectances are measured by a spectrophotometer which is subsequently converted to required color coordinates such as the CIELAB1976 coordinates. The rest of the unknown LAB values are then predicted by various techniques.

In the present investigation attempts were used, for the first time, to make use of fundamental color stimuli (Rfcs) in an artificial neural network in order to enhance the performance of the conversion/prediction technique.

An artificial neural network (ANN) is usually utilized when a complex non-linear relationship exists between an input and an output as is the case for color profiles. However, in a LUT method based on a linear technique, for instance the cube, the relationship between inputs and outputs is linearly calculated for 8 nearest neighbors. This means, the errors are not only large due to assumptions of linearity, but also the errors will never be smaller than the actual differences between such neighbors.

To overcome this existing problem in a LUT color profile prediction, use was made of an artificial neural network to nullify the linearity assumption aided by utilizing fundamental color stimulus (Rfcs) to additionally minimize errors in the predictions. In this investigation RGBs were converted to Rfcs equivalences by the use of the matrix Q as defined by Cohen and Kapoff. These RGBs were subsequently used as inputs for training an artificial neural network. The outputs for such a neural network were the corresponding calculated Rfcs values derived from measured reflectances of printed color patches.

The results show that using LUTANNRfcs (i.e. LUT-ANN-Rfcs combination) great improvements were attained. The mean color difference between actual and predicted values (i.e.MDE) for LUTANNRfcs for the 125 samples set was 1.78 while MDE for the normally used LUTCube, was 2.13 which illustrates an improvement of about 16%. Even for the 1000 samples set the MDE was 0.70 for LUTANNRfcs and 0.79 for the LUTCube showing about 12% improvement. Therefore it can be concluded that the use of artificial neural network aided by fundamental color stimuli enhances the performances of color profiling procedures.

# The effect of background lightness on perceptual color difference

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## Abstract

During decades it is usually of interest to know the parameters which influence the visual color difference. The CIE Technical committee 1-28 on Parameters Affecting Color Difference Evaluation has introduced a set of 6 parameters which influences the perceptual color difference. These parameters include sample's size, separation between sample pairs, luminance, magnitude of color difference, sample's texture and background color. Although it has been well known that these factors can affect the color difference evaluations, the circumstance and the kind of these effects have not been well identified yet.

In the present study the effect of background lightness on perceptual color difference were evaluated. To this end, three backgrounds including a white, a middle gray and a black card were chosen. Samples were prepared in 4 color centers closed to red, yellow, green and blue using a Hp Photosmart Pro B8850 photo printer. In each color centers, 4 specimens which had almost lightness difference were produced. The spectral reflectances of the printed colors were measured using a GretagMacneth Eye-One spectrophotometer in the range between 380nm and 730nm. The visual assessment was conducted using a VeriVide light cabinet with an approximately 0/45 illuminating/viewing geometry under the D65 simulator. 16 observer including 8 women and 8 men carried out the visual assessment with common gray scale method according to ISO A02 standard. For each background, all the pairs were evaluated continuously. In the other way, all the samples were assessed on the first background and then the experiments were repeated on the second background and so on. Each observer was asked to estimate the magnitude of the perceived color difference in a test pair in terms of the gray numbers 1-9. The observers were permitted to use mid-number by a step value of 0.25. The gray scale rating for each pair was converted into the corresponding visual color differences using curve fitting method.

The obtained results show that, background lightness obviously influences the perceptual color differences. It can be seen that this effect depends on the color center of the samples. All the samples show their lowest color difference on the black background. The visual color difference of blue and red pairs is averagely decreased by decreasing the background lightness. They show the maximum color difference values on the white background. For the green samples, the color difference on the gray background is higher than the white one. The yellow pairs behave almost between red and green.

# Color as a light source and the receiver's participation

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## Abstract

In the field of New Technologies of Communication (NTC) some artworks stand out because of their characteristic way of handling materialized color by light sources. Such light sources are poetically articulated by the artist, and they can enhance the dialogue between artwork and receiver. The aim of this article is to investigate how the light-sourced color manipulated by the artist using NTC technological devices can promote an environment of synergy and exchange of information with the receiver.

In order to achieve the aims of this article, it was necessary to know the historical panorama that laid the foundation for the appearance of the light-sourced color; to do so, the first part of the article aims at recovering the main scientific contributions to the study of the light-derived color, and the intention was to highlight how such contributions are at the basis of the digital artistic experiments. The second part of the article presents information which includes the study of color as a phenomenon, and its physical, physiological, psychological and cultural aspects are detailed, because they are essential as a basis for the specific study of color. In this part the importance of perceiving color not only as a physical element, but also in its subjective character was emphasized. The third part of the article deals with capturing the spectator's attention in the passage from the classical to the non-classical art: it shows how the spectator moves from the role of a spectator to that of interactor, that is, the role of a transforming agent of the artwork itself, because of the possibility of being incorporated in the reception not as a person who merely enjoys the artwork, but as a transforming agent himself. In the fourth part of this article, it was possible to examine artworks that were produced on the basis of NTC and that have used color as a light source in order to insert the receiver in an instantaneous participation. In this part, we intended to identify the different ways color from a light source can be manipulated by the artist, considering the role of color as essential and active in the dialogue between receiver and artwork.

We conclude the light source was a new datum introduced little by little in art. Its use is associated with the impetus of change resulting from the artists´ interest in adopting the most recent scientific discoveries. We realize the importance of the use of color as a way to insert the receiver since we consider the presence of the information provided by the color as something that makes the poetic proposal dynamic and real.

# Multispectral imaging system with multiplexed led illumination for spectral and color measurements

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## Abstract

Multispectral imaging systems are known to be suitable for many situations in which the interaction of light and matter is used to reveal the appearance or constitutional characteristics of a sample. Herein, we present a multispectral imaging system prototype that uses commercial elements for its implementation and covers the range of wavelengths from 350nm up to 1650nm. This wide range of wavelengths is covered using two different modules. The first module comprises a CCD camera as imaging sensor and an LED illumination source with 16 wavelengths of emission. The second module uses an InGaAs camera and an LED illumination source with 7 wavelengths of emission. With this hardware a stack of 23 different spectral images are captured and saved as the raw information for further processing.

The system allows pixel-to-pixel extraction of the spectra of the sample using estimation algorithms (Moore-Penrose pseudoinverse or Matrix R method), when a proper training with calibrated samples is performed. Results of accuracy in the spectral estimation of the system are provided in terms of the RMS and GFC metrics. Furthermore, the prototype also allows obtaining colorimetric information of the measured samples using only the data coming from the visible range. The performance in color measurement is assessed through the color difference formula CIEDE2000. Additionally to it, complementary algorithms are also implemented: a procedure based on the capture of a grid of circular spots under measurement conditions serves for the correction of possible distortion artifacts coming from the acquisition process, and a flat-field algorithm is used for the elimination of the illumination inhomogenieties. The spectral reflectance reconstruction of the sample achieved by the whole system is firstly evaluated through computational simulations and validated over real samples. The results show the feasibility of the system and its possibilities in the study of artwork as well as in other applications related with food technology, digital archiving or paints in which spectral and colorimetric information have a relevant role. However, it also shows the necessity of further development and improvement in the illumination sources and the automation of the prototype.

# Mandarin color terms eliciting from free color naming task

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## Abstract

The purpose of present study is profiling the usage of synchronic Mandarin color terms by conducting an empirical survey. The behaviral data in color naming experiment are considered to be the important mirror reflecting the inate structure of color perception. Also, some anthropological linguistics believe that the number and the evolution of basic color terms are related to culture maturity. The amount of basic color terms and the diversity of secondary color terms could serve as plausible index of complexity of visual culture. The color naming studies has been intensively examined in many languages, such as Berlin and Kay's studies. However, there is not much empirical observations regarding color naming in Mandarin. In this study, the researchers conducted a free color naming experiment with 36 native Mandarin speakers as participants. There participants were screened with Ishihara test. All participants are native Mandarin speakers capable of using spoken and written Chinese. There are 121 evenly sampled stimuli sweeping the 50 cd/m2 level of CIE x-y diagram within the available gamut constrained by the display media. The participant were presented with the stimuli and then asked to freely name the color in written Mandarin on a trial. They were also stressed to respond as fast as possible, and they were aware of that the response times were recorded. Further, following the production of a name, the observers were asked to give a confidence rating along a scale of one to five. The results are:

1. Locating the foci color of lexical color categories in color naming space within Mandarin speakers.

2. Collecting and classifying large number of Mandarin color terms with rich diversity. The classes of color terms are landmark basic, other basic, Mono-lexeme Secondary, Modifier-Basic, Modifier-Secondary and Complex.

3. Comparing the naming results and behavioral data such as response times confidence rating, and the occurrence rate of each class. There is remarkable difference in the quantity of various classes of color terms, if comparing our results with English color terms in the previous study elicited from similar task.

# High color-rendering color tunable LED lighting for mediating noon drowsiness and mood

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## Abstract

Many people have experienced afternoon drowsiness especially right after lunch. Increased this sleepiness is recognized as a detriment to work efficiency in office. High bright natural light exposure is an effective alternative. However, it may not be available for indoor environments such as in the core of a building. High color temperature (CT) lighting might be a choice to easy this sleepiness since people will induce high arousal level by high CT illumination. The arousal levels induced by different color temperature of illuminations are interpreted by the alpha attenuation coefficient (AAC) which is the ratio of the alpha power of eye-close and eye-open in measuring brain wave by electroencephalogram (EEG). Our experimental results show long time exposure to high CT illumination will not gain the same time duration of arousal level. The ACC value will decay after 30 minutes of the exposure of high CT illumination. This might be interpreted as the adaptation of the eye to the high CT illumination. Thus, a higher CT illumination might be required to have people maintain high ACC. Besides, we may need different color temperature illuminations depending on different needs for different persons at different time slots. Therefore, a color-temperature adjustable lighting with high color rendering (CRI) is required to replace the conventional fixed color illumination. A color temperature tunable LED light source is fabricated with 6-channel LEDs and with high color rendering index accordingly. The selection of these LEDs is based on the optimal algorithm and selected from the collected 61 LEDs from the website of some LED companies. Thus, different from exposing to a fixed high color temperature illumination which is a conventional lighting that we are using to date, the color temperature tunable LED light source is applied and shows that it can not only ease the afternoon drowsiness but also mediates our mood based on different people with different needs in a working place. Because of color adjustable and high CRI, this LED light source can be used for various applications, such as light booth for color measuring, floodlight in TV studio, and general lighting such as intelligent lighting which might replace the lighting we are using now.

# Evaluation and optimization of spectral estimation algorithms for printer inks

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## Abstract

Spectral information of the printer inks is, nowadays, catching the attention of the printing society. Easy but precise spectral reflectance measurement method for printer inks is strongly desired for many applications. Two methods are generally used to measure the spectral reflectance of printer inks: one is directly measuring using a spectrophotometer, and the other is based on estimated measurements of the spectral reflectance using the camera responses of multi spectral imaging systems. Comparing to the latter spectral technique, a spectrophotometer is considered to be more expensive, more limited in measuring geometry, and more limited in spatial resolution.

In the last twenty years, there have been multiple spectral estimation algorithms and solutions proposed to deal with this problem using multi spectral systems, some based on real sensor responses and some on computational simulations of sensor responses, often adding noise to be closer to the real capture devices.

The purpose of this study is to obtain a useful set of preliminary data on which the practical development of this system could be based. We made a computational simulation of camera responses based on different sensor sets, and we evaluated and compared the performance of different spectral estimation algorithms in practical scenarios (including noise in the camera responses).

In this study, three different sensor sets and nine algorithms were tested and compared: Maloney-Wandell, Imai-Berns, pseudoinverse, Shi-Healey, Wiener, matrixR, Regularized Polynomial Regression, POCS, and a radial basis function neural network. The quality of the estimated spectrums was evaluated using three different quality indices, two spectral and one colorimetric. We additionally performed an exhaustive search for the best group of sensors in order to improve the estimation quality of the multispectral capture system. Evidence of crossed interactions have been found between the training set and the result provided by different estimation algorithms: for the non-optimal training set the algorithms based on neural networks do not offer the best quality; then, the matrixR method, Wiener or pseudoinverse could be a best choice. For a large and well designed training set, neural network could be a very promising solution. Nevertheless, the results of our exhaustive sensor set optimization show that the majority of the optimal sensors would be covering the central portion of the spectral range.

# Translucency perception

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## Abstract

The appearance of all materials depends on perceptions of colour, gloss, surface texture and translucency. This paper considers only translucency of which there are two types, pseudo and material. Pseudo translucency concerns the layering of colour patches so that one colour layer appears to be translucent. This phenomenon is an area for artists and package designers. Material translucency concerns the physical property of a material whereby light passes or does not pass through. That is, every material exists somewhere on the scale transparent to opaque. This paper deals with material translucency.

The perception of translucency depends on illumination of the sample, ambient lighting, optical properties of the material and colour contrast. Questions addressed include how do we know translucency when we see it, how is it scaled and how can it be quantified? At first glance translucency is simple of perception and understanding. But, like other attributes of appearance, this phenomenon is not totally straightforward. First, in the measurement of translucency all existing standards, for example those associated with the paper, plastics and paint industries, assume a non-pigmented substrate. This is a result of the fact that in such materials each attribute of appearance can be studied in isolation and regarded as an independent variable. This means that a specification can normally be based on contrast ratio. Work, including that carried out by the aforementioned 'idealized' industries, has been specific to the industry and little effort has been put into the study of translucency as a phenomenon in its own right. For example, for materials that absorb light as well as scatter it (i.e. coloured materials), does absorption add to perception of translucency? There are two populations of observers, one regarding coloration as increasing opacity, the second who do not.

Translucency is perhaps the most subtle and fugitive of appearance attributes. This is because the appearance of many materials, particularly organic materials such as foods, while not looking translucent, owe their appeal to translucency. Preliminary work reveals that, except in special circumstances, translucency scaling ought to be performed in terms of opacity or transparency, because translucency increases as the material moves away from transparent towards opaque as well as when it moves from opaque towards transparent.

Although we do not really know what its constants mean, use of the Kubelka-Munk approach can lead to some understanding of object appearance as well as of translucency as a whole. Brief accounts will be given of the total phenomenon of translucency and its perception, a possible approach to the phenomenon, and examples of its importance particularly in respect of foods. The last includes the use of imaging techniques for the rapid determination of industrially important concepts such as clarity, haze and opacity.

# Effects of chromatic light on visibility-distinction threshold and equivalent veiling luminance

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## Abstract

Evaluation of the visibility under the lighting by chromatic light is important to maintain safety and comfortableness. The relation between the monochromatic radiation of wavelength and the recognition sensitivity is analyzed well and known widely as, for example, spectral luminance efficiency. However, by the use only of the relation to the monochromatic radiation, it is difficult to evaluate the visibility in the chromatic light that deviates from the planckian locus extremely. Then, the authors have been researching the influence on the visibility as part of the research on the influence on the visual environment of chromatic light.

In this report, the influence of chromatic light on the visibility is examined at the viewpoint of the detail identification threshold, the luminance difference threshold, and the veiling luminance, by used the fluorescent lamps of white, blue, green, yellow and red. The experiment is a measurement of the visual acuity about the young person by Landolt ring or a measurement of luminance difference threshold by disc.

Visual acuity obtained in red light and in yellow light is higher than in another three light colors under the low field luminance. There is no significant difference between visual acuity in white light and in green/blue light. Even if the visual distance is changed, the influence of chromatic light on visual acuity is the same. As a reason of this result, there is the density difference of three kinds of the cone on fovea. The luminance difference threshold is highest in blue light, and lowest in red light. It means the lighting by red light is able to see the disc easily most. The smaller the object size is, the greater the difference of the threshold by light color is. The difference extremely becomes small when becoming 16 minutes or more in the disc radius. It is thought that these results are related to the scattering property in the eyeball. Equivalent veiling luminance by the chromatic glare source tends to become small in the case of red light source, and tends to grow in blue. The nearer the view point the glare source is, the greater the difference of equivalent veiling luminance by light color is.

Therefore, the following are the main conclusions. The distinction threshold of the detail and the luminance under red light is highest among five colors (white, blue, green, yellow, and red). Similarly, as for the veiling luminance, the case in the red glare source is smaller than that of another color. The blue glare source might have the highest possibility of decreasing the visibility because the veiling luminance is largest.

# Correcting for non-uniform lighting when photographing the mural in the royal tomb of Amenophis III (II): Applying a lighting model to mural images

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## Abstract

The Royal Tomb of Amenophis III is situated in the Western Valley of the Kings Valley, Luxor, Egypt. The murals are drawn on the four walls. We are trying to digitize the mural. About one hundred images were photographed for each scene, and 480 mega pixel images were stitched. Zoom images of the stitched images were produced and put on the Web. The zoom images are useful to many researchers in the world so that they can utilize it for their studies. When photographing the murals, two stroboscopic light sources with umbrellas were used for uniform illumination. However there is non-uniformity yet. We tried to correct lighting non-uniformity with a lighting model. Umbrella illumination can be assumed as a virtual point light source illumination. Illuminance $E$ at a point $(x,y)$ on the painting illuminated from a point light source is defined as a formula which is introduced from the inverse square law.

We applied the lighting model to a simulated painting (2.4m width x 1.6m height) which was reproduced from preliminary photographed image of the murals. At first, the model was applied for images of the simulated painting with thirty-five white patches. The relative illuminances $E$ of the white patches were calculated from digital counts, $R$, $G$ and $B$ of the white patches in the photographed image. The four constants used in the model were computed from the measured relative illuminances by using a nonlinear optimization technique. The colors of original images were corrected by using the model. Consequently, colors of white patches of corrected image were almost same. It was proved that the model was valid to the correction of lighting non-uniformity.

It is impossible to put white patches on the real murals which is an ancient monument. Almost same color areas of background on the paintings should be used instead of the white patches. Digital counts of forty-four almost same color areas on the image were measured. And the colors of real image were corrected with the model and values of four constants computed from the measured digital counts. The corrected image seems like a uniformly illuminated one. This means that lighting non-uniformity of an image can be corrected from only the image itself by using the lighting model.

In this study, we extended the lighting model to two virtual point light sources. The extended model was applied to real photographed images of the murals. Consequently, it was found that the lighting model developed in this study improved the images to more uniformly illuminated ones.

# Effect of correlated colour temperature on individual variation in the impression of lighting with regard to season

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## Abstract

People are exposed to the changing level and amount of illuminance during a day or a year. And the changing one is the colour of light as well as the illuminance. We have received various influences from such changes and adapt our sensibility of lighting to environment. Therefore, it is important to clarify the relation between the subjective assessment and the illuminance or correlated colour temperature change through one year. This study investigates how the correlated colour temperature and illuminance affect the impression of lighting in summer and in winter. However, subjective evaluation inevitably has individual variation. So the purpose of this paper is to clarify how within/between-subject variation changes, in case of correlated colour temperature and illuminance change in summer and in winter.

The size of the evaluation room is W2.7m x D2.7m x H2.6m, the floor reflectance is 26 percent and the wall reflectance is 93 percent. The lighting is a uniform luminous ceiling set in fluorescent lamps sized with 2.7m × 2.7m, and it can be adjusted from 0.5～2000 lx. The experiment variables are three: 1) The correlated colour temperature of fluorescent lamp (3000K or 6700K). 2) The vertical illuminance at the subject's eyes position (12 levels, from 0.5 lx to 2000 lx). 3) The season （summer or winter）. The subjects are 27 to 31 healthy young women. They evaluate 4 items which are brightness, glare, comfort and relaxation of the lighting.

In conclusion: 1) The illuminance has a great influence on within-subject variation in brightness, glare and comfort. The relation between the within-subject variation and illuminance has the similar tendency, even if the correlated colour temperature and season change. The effect of the correlated colour temperature to the within-subject variation is smaller than the effect of illuminance. 2) The between-subject variation receives the influence by the correlated colour temperature as well as the illuminance. The illuminance range in which the difference by the correlated colour temperature appears is different in each evaluation. In case of changing correlated colour temperature, the difference between the between-subject variation in 3000K and one in 6700K is bigger in the summer than that in the winter. 3) Regardless of correlated colour temperature and season, the between-individual variation is larger than the within-individuals variation, although there is little difference depending on the illuminance.

# Effect of knowledge and experience of fabric on the cross-modal linkage between tactile sensation and visual image of solid black and multi-color printed fabrics

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## Abstract

The purpose of this study is to investigate the effect of knowledge and experience on the ability of fabric identification using visual and tactile information as well as to explore a key property of image to be used in the cross-modal linkage. We carried out two fabric identification experiments with using only solid black fabric (Experiment 1: E1) and both the other solid black fabric and multi-color printing (Experiment 2: E2). These experiments were done by two subjects groups – engineering and clothing students, however, these of the E1 and E2 are difference. Two kinds of pictures with and without drapes (Pattern A, B: PA, PB) were employed for the cloth image. Result of the E1 indicated that clothing students showed better performance than engineering students, and average percent correct was statistically higher in the sessions showing the picture of PA than that in the sessions showing PB. However, no significant difference was observed indicating that the showing the fabrics on just before the experiment does not contribute to form the linkage between visual and tactile recognition. Results comparing the two groups indicate that knowledge and experience on fabrics accumulated for a long period form a rigid linkage between visual image and tactile sensation in subject brain and it contributes to combine tactile sensation to visual image in order to label the certain fabric name to the cloth with the aid of knowledge database. Results comparing the two patterns indicate that more useful information is included in the PA than PB. Therefore we calculated the skewness and kurtosis of images for the cloths of both PA and PB. In the case of PA where a large variation is found for both skewness and kurtosis among the images of different cloths, multiple linear regression using those two values showed a strong correlation to the percent correct of the cloth identification. Weighting coefficients of the skewness is much larger than that of kurtosis for both clothing and engineering students' results. In contrast, no correlation between the skewness and/or kurtosis and the percent correct of the fabric identification was observed in the case of PB where neither skewness nor kurtosis showed large variation among the images of different cloths. On the other hand, result of the E2 indicated that no significant difference was observed on the two groups, whereas average percent correct showed the same tendency as the E1. These results indicated that further investigations of the quality of subjects' experience on the fabrics, the criterion for selecting cloths et al. are required.

# Determination of spectral dimensions of Munsell neutral samples

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## Abstract

In this article, the dimensional behavior of the neutral samples of Munsell sets is investigated.

According to the Munsell color system, the perfect gray samples, i.e. the achromatic colors, locate in the line with the chroma values of zero. The values of actual neutral samples change between 0.5 to 9.5 with the steps of 0.25. Therefore, a set of 37 neutral samples which benefit from C=0 and different V values are available.

The principal component analysis technique is employed on the reflectance spectra to analysis the dimensional behavior of samples. By this way, the most important directions of reflectance dataset are extracted and their corresponding cumulative variance percentages calculated. Up to five eigenvectors are extracted due to the spectral behaviors of samples. Besides, the reflectance spectra of samples are compressed in the reduced spaces and then are reconstructed by employing the linear combination of the weighted sum of characteristic vectors. The recovery errors are investigated spectrally and colorimetrically by calculating the root mean square error percentages and the color difference values between the original and the reconstructed spectra. The color difference values are measured under C, D65 and A illuminants and the 1964 standard observer.

Results show that, while the neutral samples are visually identified as one dimensional objects, spectrally they are two dimensional samples. In other words, one dimension is missed during the conversion of spectral data to colorimetric information.

To interpret such achievement, the samples are introduced in CIELAB color order system by calculation of their XYZ tristimulus values under C light source and 1964 standard observer. The corresponded metric chroma, i.e. C* and lightness value L* are calculated. The outcomes show that samples benefit from different hues with different degrees of saturation while, visually they form the neutral gray samples of Munsell chips with the chroma value of zero. In fact, while the samples visually form a one dimensional system, their spectral and the CIELAB color behaviors do not confirm such sensation.

# Comparative study of color emotion of university students between Korea and Canada

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## Abstract

Today, the color takes an important position to move consumers' emotion in the era of globalization where there are active interaction among countries in fields of political, economical, cultural, and etc. The purpose of this study is to compare the color emotions between the East and the West by researching the color emotions of Korea and Canada. The samples of this study are 150 university students in Korea and 198 university students in Canada. The study conducted a survey using PCIS (Psychological Color Image Scale) color charts of hue and tone. The survey asked to select a like color and a dislike color within 5-6 seconds, then analyzed by categorizing like color, dislike color, like hue, like tone, dislike hue, and dislike tone.

The study result finds similarities and differences in color emotion between Korea and Canada. The first similarity is that both countries university students like 1080-R, 1050-B, 1565-B, and 9000-N colors and dislike 6020-Y color. The second similarity is that B class hue and bright tone have high preference. The third similarity shows that Y class hue and dkg tone are highly disliked. The differences of both countries' color emotion are as follows. First, there was different preference rate on RB and R class hue and, light, vivid, deep and neutral tone. Second, both countries differed in disliking YR class hue and dark, deep, and neutral tone. Third, the likeness of gray class hue in Canada and the likeness of light grayish and the dislikeness of white class hue in Korea showed 0%. A color is used as a means of communication with other countries and the color shows the characteristics of the country and its citizens in the globalization. Therefore, it is necessary to study on color emotion consistently to comply with the globalization.

# Extension of colour emotion model for complex images

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## Abstract

The purpose of this study was to investigate the relationships between the image colour characteristics and the emotional responses including three factors of colour emotion (colour activity, colour weight, colour heat) and overall emotional responses (preference, pleasantness and excitement). A psychophysical experiment was conducted using ten images presented on a 40" LCD screen, manipulated in terms of image colourfulness, lightness contrast, and lightness. Seventeen observers were asked to assess the images using 9-step scales of pleasant-unpleasant, arousing-calming, like-dislike, warm-cool, heavy-light, and active-passive. The experimental results showed that image colourfulness, lightness and lightness contrast had a consistent influence on the observers' responses of colour emotion and image emotion. The responses of image emotion were significantly affected by the image content whereas the responses of colour emotion were not. Therefore, the model of colour emotion factors are developed for all images. Overall emotional responses for complex images in terms of pleasantness and excitement were developed as a function of colour attributes and factors of colour emotion model for positive and negative image groups separately.

Three factors of colour emotion model: activity, weight and heat for complex images were developed as a function of image colourfulness, contrast and lightness. According to these model developed, colour activity of images can be enhanced by increasing image colourfulness, colour weight by increasing contrast of decreasing lightness and colour heat by increasing colourfulness. For the model of image emotion, we can enhance image excitement by making the colours more active and warmer for images which include positive contents. For negative images, image pleasantness can be enhanced by more passive and cooler colours. Image excitement can be enhanced by more active, heavier and warmer colours.

These models:colour emotion and image emotion models could be used to modify images to have a set of pre-defined emotional qualities. Comparing the two colour emotion models, one as a of colour attributes and the other as a function of three colour emotion factors, the one based on colour attributes performed better. However, having the model as a function of colour emotion factors enables us easily to get the idea of strategy to enhance the overall emotional impact of images.

# Perceived colour in transparent materials and objects

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## Abstract

The aim of this multidisciplinary research project is to explore the human perception of transparent glass colours and also to create a virtual tool that can make it easier to communicate the mental notion of the colour. In a previous pilot study, the traditional Natural Color System (NCS) atlas and its virtual form were used to represent the perceived colour for transparent glass samples. The main difference between the opaque surface colours and transparent colours is the light that is transmitted through the object, which requires special viewing conditions. The transparency also suggests that the perception of transparent colours depends on both concentration of the colouring agent and the sample thickness.

In the current study, the joint effect of colour concentration and sample thickness - the optical density of the sample - was investigated for three transition elements in glass: cobalt (Co), chromium (Cr) and iron (Fe). The colours were defined by trained human observes (NCS notation) as well as measured by spectrophotometer (CIELAB). The human observers used two different techniques: 1) The glass sample was placed on a metal frame 5 cm above a white surface and the colour was matched with the opaque colours in the NCS atlas. 2) The sample was placed on the computer screen and the colour was matched with screen images of the NCS colours.

The results show that NCS whiteness (w) decreases more or less exponentially with increasing optical density, in a very similar manner for both observation techniques. NCS chromaticness (c) increases first but at higher density values it either levels off (Co) or reaches a maximum and then decreases (Fe and Cr). Blackness (s) increases with increasing optical density (Fe and Cr) or levels off at higher densities (Co). For all samples, colour perceptions from technique 2 appear to have higher chromaticness and lower blackness. For Co and Cr, the difference in hue (Φ) between the two techniques is quite small and it decreases with increasing optical density. For Fe, the difference is larger and it remains roughly constant throughout the density interval. The vivid blue colour of cobalt glass cannot be matched by opaque colours at higher optical densities. An interesting notion is also that the most intensely coloured cobalt samples appear to have a distinctive red tint. The main conclusion is that increasing colour concentration and sample thickness cause non-linear variation in both hue and nuance, and this variation is also different for different colouring agents.

# Teaching color to architecture students

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## Abstract

Teaching principles of color to architecture students is a challenge different from teaching color to artists. In the education of architects, the aspect of color plays rather a marginal role and in the architectural planning process it is often considered a component that is secondary to the design of the plans or the shape and structure of the building.

In the actual experience of architecture however, color is via the materials that make up the surfaces of buildings and spaces, an integral part of the perceptual process. How can this dichotomy between reception and production of architecture be resolved? How can students of architecture be taught to imagine the first ideas about architectural shape and space as material ideas right from the start, instead of merely draping an already finished design with color and texture?

In recent years, the curriculum at the Institute of Spatial Design at the Department of Architecture at the University of Dresden has been considerably revamped in order to better integrate color. Rather than teaching the systematics of color theory, which then become more or less successfully applied to design, we chose to investigate the components of light, color and shape as part of an integrated whole.

During foundation courses the students are first familiarized with color as a material, here they learn to understand the systematics of color as a result of experimentation and reflective thinking. Beginning with the manufacturing of their own colors from various natural materials and the production of a multitude of large color swatches they comprehend color as a sensual medium. Analyzing colors in nature and in architectural surfaces, the students begin to understand the many facets of color and their importance in architecture.

At the graduate level students investigate the various connections between the components of: Spatial Geometry, Surface, Color/Texture and Light in terms of their spatial appearance and atmosphere. The underlying idea is that atmospheric characteristics of architecture can be systematically analyzed and subsequently taught as principles. One of the teaching exercises used is the transposition of specific atmospheric situations shown in one particular medium, e.g. drawings, photography, models, text, etc. into other respective media.

In this context we will also discuss the role of a Collection of Color-Materials, the so-called 'Samlung Farbenlehre' which was established 150 years ago at the University of Dresden and is still an active tool in teaching and research.

# Whiteness of paper containing fluorescent whitening agent under white LED and fluorescent lamp illumination

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## Abstract

White paper used in the office and the home contains fluorescent whitening agents to increase perceived whiteness, and the whitening effect changes with the amount of near UV radiation in the illuminating light. However, the main type of white LED for lighting currently sold at market combines a blue LED with yellow phosphor, and does not have emissions in the UV or IR spectrums. In this study, the perceived whiteness of white paper containing fluorescent whitening agents under both a white LED and a fluorescent lamp was visually evaluated, and its relationship to the whiteness index was considered.

Three types of white paper containing fluorescent whitening agents were used as samples. A daylight-color LED and a three-band type fluorescent lamp were used as light sources. A white LED and a fluorescent lamp with nearly the same chromaticity were selected.

The total spectral radiance factors of white paper samples were measured under both the white LED and the fluorescent lamp using a spectroradiometer. For each sample, the fluorescent radiance factor in the short wavelength region is lower under white LED illumination than under fluorescent lamp illumination. Visual evaluations of perceived whiteness by paired comparison were made for a total of 6 conditions: 2 illumination conditions and 3 sample conditions.

The results of the visual evaluation experiment show changes in the perceived whiteness of each sample between the different light sources. The CIE whiteness and the value of the *C/V* index developed by the author were calculated for each sample, and their relationship to the results of the visual evaluation was considered. As a result, the values of the *C/V* index showed good correlation ($r = 0.882$) with the visual evaluation results, but no significant correlation was seen ($r = 0.304$) between the CIE whiteness and the visual evaluation results.

The following conclusions were obtained.

(1) Bluish tint due to fluorescence decreases under white LED illumination as compared to fluorescent illumination, but the perceived whiteness of white paper may decrease or increase depending on the case.

(2) The change in perceived whiteness between types of illumination cannot be predicted by the CIE whiteness, but the *C/V* index developed by the author is effective.

# Colorimetric prediction of halftone prints with pale-ink model

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## Abstract

In the offset processes or digital printing, photographic images are printed onto paper by converting them into halftone dot patterns. Dot size is measured in terms of dot area. The difference in dot area between an original dot and its reproduction is called dot gain. Efforts to account for optical dot gain are of practical importance in graphic arts, and the topic has long been an interesting subject of research from theoretical, simulation and experimental perspectives. The Murray-Davies model describes image reflectance as a linear combination of ink dot and paper reflectance. The Yule-Nielsen model is compatible with offset printing. This provides a numerical approximation, but does not provide any physical insight into the actual constituent materials.

In this study, we create a model in which pale-ink is introduced in consideration of light scattering term and investigate the validity of the model. Our goal is the development of a generally usable model by examining the ways in which the material characteristics are considered. The pale-ink reflectance spectrum is estimated based on the modified Beer-Lambert law, which was introduced to estimate the attenuation of light for scattering media. The path length factor and scattering loss factor are estimated from the modified Beer-Lambert law. In the pale-ink model, the reflectance spectra of the pale-ink, solid area, and paper substrate are converted to XYZ tristimulus values, and the actual colour is predicted by a linear combination of weighted tristimulus values.

From the results, the optical path length for the light that passes through the colorant of a halftone dot image is considered to be about 40% of the mean optical path length of the solid area. The pale-ink represents the scattered light of the halftone dot section, and is believed to correspond to the optical dot gain. The weighting factor for the pale-ink in our model is parabolic, with the maximum estimated at about 33%. Accordingly, if the dot gain is measured at 20%, the optical dot gain is estimated at approximately 7%. And we understand that pale-ink model can accurately reproduce the change of hue in accordance with the dot area ratio.

We attempted to predict dot gain using our pale-ink model and found that our proposed model offered improved prediction accuracy over the conventional Murray-Davies and Yule-Nielsen models. The results of our examination indicate that the proposed model adequately explains the effects of the ink properties and paper substrate on optical dot gain. From a practical point of view, this model is expected to be helpful in efforts aiming at understanding the effects of dot gain on hue.

# Performance of multi-angle spectrophotometers

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## Abstract

Due to their unique visual appearance, inks with special effect pigments are used more frequently for high quality printing products. For process control and quality assurance of such gonio-chromatic materials, multi-angle spectrophotometers have been developed by manufacturers of colour-measuring instruments.

In this study, three commercial multi-angle spectrophotometers are investigated in their performance using statistical parameters. Univariate and multivariate methods are applied to evaluate repeatability, reproducibility and accuracy of the BYK-Gardner's BYK-mac, Datacolor's Multi FX10 and the X-Rite's MA98.

The measurements with the three commercial multi-angle spectrophotometers were organized in two test sequences from seconds to minutes and from hours to days. Short-term and medium-term measurements were performed on three samples. A white reflection standard and two printed samples of a special effect ink on white and black paper were also measured with a reference instrument. The robot-based gonioreflectometer of Physikalisch-Technische Bundesanstalt, the National Metrology Institute of Germany, was used for reference measurements.

The univariate mean colour difference and the multivariate ellipsoid volume were determined for six geometric configurations of light source and photo detector within the half space above the sample. For an incidence angle of 45°, aspecular angles of -15°, 15°, 25°, 45°, 75° and 110° are realized in all instruments. Polar-like plots relating statistical parameters to the aspecular angle serve to evaluate influences of test sequence, measured sample, statistical method and geometric configuration on the performance of the investigated multi-angle spectrophotometers.

Short-term repeatability without replacement was found to be better than medium-term repeatability with replacement. Compared to the printed samples, repeatability is better for the white reflection standard. In addition to the white standard, repeatability should also be evaluated for other samples like printed special effect inks.

Univariate and multivariate methods show the same geometry-dependent performance trends. Reproducibility and accuracy are less good for geometric configurations with detection near specular direction. Further investigations are necessary to identify the reason for these deviations.

# A study on appropriate correlated color temperature subsequent to activity types of housing space

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## Abstract

In order to secure comfort and pleasantness in room space, which the light environment using illumination could be used as an aesthetic element having variability that can create diverse spaces. Since the invention of lighting, light has played an important role in human beings' life, and the function and role of light become diverse according to the change of periods. Particularly, light is dealt with as a vital environmental element influencing man's psychological and mental aspects, let alone visual functions that can help the men in modern times to recognize information.

According to results by Kruithof , the scope of lighting environment that gives pleasant feelings to men is already designated and its scope is determined by color temperature and the intensity of illumination. However, the recently released research results show that the scope of a pleasant realm is the result from not considering the sorts of room activities, so the scope isn't always useful in real life.

Accordingly, this research conducted an experiment to more substantially examine the realm of color temperature favored by people according to the work pattern in residential space. For this experiment, this research manufactured a mock-up model sizing 3x4x2.7m, and suggested the room environment of living space by composing them on Mock-up model. In addition, through preliminary experiments, this research got the experiment group to assess the preference for lighting environment while they were working in person inside the Mock-up model by classifying the sorts of work that could happen in room space into the 'general', 'work', and 'rest'.

The lighting equipment used in this experiment was applied by the light source of LED lighting; in short, this equipment was manufactured so that adjustment of color temperature is made available by using two sorts of cool white and warm white of LED Chip. In this experiment, this research assessed the preference subsequent to the sorts of work by space by suggesting color temperature on a total of 7 stages (3000K~6000K).

As a result, there appeared diverse scopes of color temperature favored according to the sorts of work in the same space according to space pattern. Particularly, it was found that the scope of higher color temperature than other spaces was preferred in a study room in comparison with other spaces. In addition, notwithstanding the same sort of work, there appeared the scope of color temperature felt appropriate by space pattern differently. In the space for 'rest', low color temperature at a level of about 3000K was preferred while in the space for work, the color temperature at a level of 4500~5000K was found to be favored.

# Research on the influences self image has on the preference of visual image and visual color – focused on Korean females in their twenties

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## Abstract

The purpose of the research is to identify the tendency and emotional wants of consumers. Subjects to the research were Korean female students in their twenties who are the leaders of trends and the principal sources of economic activities. Research was conducted by analyzing actual self-image and ideal self-image which are the most important factors in influencing consumer brand evaluation (Sirgy, 1982, 1985). IRI adjective image scale made in 1992 to meet the Korean mind was used as a basis. This research can be divided into three parts. The first part indentifies the actual and ideal self-image of Korean women in their twenties. We asked 198 female students directly about the emotional group of their actual self-image, ideal self-image and asked them to identify an adjective describing their images. The second part extracts representative triad colors of perfume advertisements that can influence one self. In order to gather perfume advertisements of different brands, we searched ELLE and Vogue magazines that were published from 1996 to 2010 and gathered 86 perfume advertisements. To analyze the visual emotion of the advertisements a survey was conducted on 30 professors and lecturers, professionals of visual communication design, of Ewha Woman's University, School of Design. With the IRI adjective scale we asked them to identify each advertisement's images with the 12 emotion groups. The last part identifies preferred visual emotion image and the colors of the Korean female students in their twenties with the perfume advertisement. The 198 female students in their twenties were asked to choose their preferred visual emotion image between the 36 advertisements that exclude the IRI adjective scale standards. And with the results, through image clustering extracted the representative triad colors and its values into L*, a*, b* and changed those values into Munsell. As a result, when compared adjectives from the IRI image scale and preferred visual emotion image, verbally 'natural', 'cute', 'airy' and visually 'cute', 'airy' showed a high preference. This means that 'cute' and 'airy' reflects the general self-image of the female students in their twenties in Korea. Analyzing the colors of preferred visual emotion image, Hue is distributed P-R and, Value is distributed 5-10 mostly, Chroma is distributed N-14. The research resulted that the majority of Korean female students in their twenties have identical self-image, verbally and visually, and generally showed a high level of color in the pale, light, bright, vivid P-R range reflects their self-image.

# Colour and light in space: Dynamic adaptation and spatial understanding

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## Abstract

This paper discusses the role of adaptation of colours and light in space in relation to own observations and to scientific and scholarly references. It is based on an ongoing work on colour and light in space, the aim of which is to formulate a spatially based colour knowledge.

The spectral distribution of light energy influences the colour we perceive, but the perceived colour varies much less than the differences of wavelengths could give reason to believe. Adapting to current light conditions we perceive almost the same colour of objects independent of the light, on condition that the light source emits light with a full, continuous, spectrum and that we have had time to adapt to the light situation.

What make us determine the lightness of surfaces we observe in different situations has been thoroughly considered by professor Alan Gilchrist et al. Gilchrist et al. discuss how we perceive lightness in areas that are very near neutral grey, colours with so low chromaticness that you can ignore the hue.

In our research we have gone further and studied colours that have nominal hue and chromaticness. We have tried to find out if surfaces with nominally chromatic colours under special circumstances can be perceived as white and thus serve as anchors for perception of other colours in the field of vision. We have also tried to find out if this anchoring may affect not only lightness perception but also the perceived hue of other colours seen simultaneously. With observers we have tested how he nominal hues of light colours affect the perceived hues of darker colours in the field of vision. One of these observation series was carried out on a LCD Monitor, where 45 combinations of whitish and greyish colours were shown to 10 observers who were asked to assess the hue of the darker colour with reference to NCS elementaries. Our studies indicate that the perceived white can be an anchor also for perception of hue.

Adaptation is, however, not limited to basic perception. Adaptation also is a result of senso-motoric skills dependent on experience of colour and light in spatial situations. We do not attend or give interest to accidental light situation. But intuitively the logically distributed variety of colours caused by light are indispensable spatial qualities. What we feel 'beyond' the perceived and temporarily colour is a more permanent 'constancy colour'; experience of colour in space is both perceptive and cognitive. To understand and describe colour phenomena it is necessary to regard them as integrated in the comprehensive and dynamic processes of understanding the world as a whole.

# La couleur, fille de la lumière: The interaction of colour and light in the monastery of Sainte Marie de la Tourette

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## Abstract

Le Corbusier's architectural work, beginning in the early 1920s, reflected his profound research and interest in colour as one of the 'fundamental elements in the architectural perception' and his essays and writings about colour stress its significance. Derived from a perception of his self as a person uniting painter, architect and sculptor, he searched for commonalities between the three major art disciplines rather than emphasizing academic difference. This internalization of a synthesis of the art disciplines allowed Le Corbusier to shift experiences from one realm to the other. As a result his paintings, sculptures and buildings share fundamental principles such as layering techniques, ordering principles, and a polychromy based on the same fundamental rules. Building upon his experiences collected as a painter at the beginning of the 1920s together with Amédée Ozenfant, and as a consequence of the modern plan understanding space as a spatial continuum rather than added volumes, he developed the concept of his *polychromie architecturale* acknowledging the sculptural and spatial potential of colour in architecture.

Transforming his purist concept of *polychromie architectural*, 'Colour completely depends on the material form,' colour began to emerge in his buildings, after World War II, as an autonomous design feature in the interplay of architectural elements in his structures. As starting with the purist buildings of the early 1920s, Le Corbusier used colour in direct-relationship to the quality and quantity of light received in his structures enhancing the sculptural, spatial and emotional response potentials of each hue within the space. In his own words, 'colour, daughter of light,' revealed itself in his works by showing the physical interdependence of colour and light.

The Monastery of Sainte Marie de La Tourette in Eveux-sur-l'Arbresle, France, built in the late 1950s is a striking example of his mastery of juxtaposition of raw materials, light and colour. In the church, boldly applied primary colours create visual tension against the grey concrete, allowing colour to take an autonomous role in the interplay of architectural elements for dramatic, perceptual experience. The richness of the painted surfaces, and the glowing colour, created through reflections of natural light onto its boldly painted walls and sculpted objects, such as demonstrated in the sacristy and the crypt, stand in stark contrast to the crude, 'bare' concrete to create a sense of pureness, as akin to his early whitewash ideas seen in his Law of Ripolin. The use of industrial, raw products, such as concrete and cement, paired with a sublime but controlled play of colour and natural light, too, mediates between the profane and the sacred to create a space of spiritual asceticism. This paper investigates Le Corbusier's use of colour and light in the Monastery of Sainte Marie de La Tourette, and relates its research back into the broader historical context of his and other architectural works.

# A consideration on mathematical relations between color attributes of Munsell, PCCS, and NCS

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## Abstract

Quantitative representation of perceptual color is useful both for analysis and synthesis of color combination in the field of application of color. Many color systems, such as Munssell, NCS, PCCS, and so on, are developed to define perceptual color by means of their color attributes:

(a) Munsell system has three color attributes, hue, value, and chroma, which are said to have uniformity separately, but it is difficult to define a tone by the attributes.

(b) NCS has four fundamental attributes, blackness, whiteness, chromaticness, and hue. The first three attributes compose a barycentric coordinate system (color triangle) useful for representing a tone, however the hue scale has no uniformity. NCS also has an auxiliary attribute, value *v*.

(c) PCCS, Practical Color Coordinate System, has intermediate characteristics of Munsell and NCS, whose three attributes are Munsell like hue, Munsell equivalent lightness, and NCS like saturation. Because the attributes of each system are defined separately, there is no explicit relation between them. The aim of this research is to find mathematical relationship between color attributes of several perceptual color systems. The relationship will reveal the meaning of each color attribute and lead us to construct a more useful and applicable color system. As each perceptual hue of Munsell, PCCS, and NCS is assumed to have the same meaning, hue is always fixed in the following, and only other attributes, such as value, chroma, etc. are considered.

**(1) Relation between Munsell and PCCS:** PCCS lightness is equivalent to Munsell value by definition of PCCS. Munsell chroma $C$ and PCCS saturation $S$ are mutually related by a linear fractional function. It is noted that, when chroma $C$ becomes larger and larger, saturation $S$ approaches to the limit saturation $S_\infty$.

**(2) Relation between PCCS and NCS:** Noticing NCS value on a fixed hue plane, all loci of constant value form a set of lines which converge at one point with abscissa $c_\infty$, which suggests that NCS chromaticness $c$ is finite ($c < c_\infty$) like PCCS saturation. Equating NCS value and chromaticness with PCCS lightness and saturation respectively, then it is found that NCS blackness (and also whiteness) is represented by a bi-linear function of PCCS lightness $V$ and saturation $S$.

The obtained relations are summarized as:

Munsell ⟷ PCCS ⟷ NCS.
     linear fractional     bi-linear

In the presentation, the relation between Munsell and Nayatani's NT-system will also be discussed.

# Factors of a harmonious landscape based on the combination of an accent color and a base color in a building exterior in Japan

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## Abstract

Japanese local governments enforced color guidelines in order to maintain the beauty of the landscape and attempted to devise architectural guidelines in order to reduce visual pollution. It is known that the color guideline is general for listed buildings in a designated conservation area. However, the landscape near the railway station in an urban area is not beautiful. In such areas, the color guideline is inefficient because the colors in the landscape are also chaotic. Even though the color guideline was enforced in this area, the power of restriction was so weak that the colors in the landscape and advertisements would not match. Although the color range was restricted on the basis of the Munsell color system, a harmonious landscape did not result. Recently, an analysis of the color guidelines for a harmonious landscape revealed a combination of an accent color and a base color in a building exterior. In detail, the ratio of the accent color in the building exterior and the base color was 1:5. Although previous studies presented different results, they were unable to provide an empirical figure.

In order to confirm the factors of a harmonious landscape in this study, participants quantitatively evaluated scenery based on the combination of an accent color and a base color in a building exterior through experimental simulations. A model of scale (1/200) was constructed to manipulate the color simulation. Its location was fixed in the neighborhood of the railway station in Kurashiki city in Okayama prefecture. The local city government restricts the composition ratio of an accent color and a base color in the color guideline. Thus, the main factors of the accent and base color were decided as hue, value, chroma, and composition ratio. Specifically, the hue of the base color was prepared for R, YR, GY, PB, and N; its value and chroma, for both high and low grades. On the other hand, the hue of accent color was prepared for R, YR, GY, PB, N, its chroma and value, for a high level. Furthermore, the composition ratio was prepared for some grades. The number of simulations became approximately 500. These simulations were shown to the participants and were evaluated according to the scale of unified evaluation for scenery.

The results demonstrated that the perception of scenery harmonious depended on "color differences" and the "composition ratio" of the accent and the base color. Furthermore, it was indicated that the accent color ratio in the building exterior scarcely influenced the perception of harmony. These results indicate that harmonious scenery should be created by taking the "color differences" and "composition ratio" of the accent and the base colors into consideration. Additionally, the process for checking the above factors should be developed and incorporated into the color guidelines for harmonious scenery.

# Research on integration of meteorological landscape and environmental colour changes – a case study of the Yangmingshan National Park, Taiwan

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## Abstract

The natural environment consists of physical elements and virtual elements. The physical aspects is composed of both physical and ecological landscape: the physical – mountains, water, rocks, topography and soil, etc. and the ecological – plants, animals and micro-organisms. The virtual aspects include light, meteorological landscape, smells, colors and other factors. The elements mentioned above interact with seasonal and daily factors to present an ever-changing natural color.

Not only are Taiwan's geographical and ecological environments very complex, but they can vary; different natural environments can produce different species and habitats. The environmental color also varies according to different climate change (such as seasonal flooding, monsoon rain and draught…etc.), different time change (such as daytime alpine clouds and evening sunsets) and different scales (such as river terraces, faults, tidal flats…etc.). These differences contribute to the landscape and environmental characteristics of Taiwan.

Among Taiwan's eight national parks, the optimum accessibility of Yangmingshan National Park is due to its proximity to the Taipei metropolitan area. With an area of about 11,455 hectares and an altitude between 200 and 1,120 meters, the park has a unique volcanic terrain, diverse fauna and flora resources and a wealth of historical monuments due to its long history of development. Constant variations in micro-climate create an ever-changing meteorological landscape, with spring rains, summer rainbows, autumn nights and winter snows. Moreover, spring cherry blossoms and autumn miscanthus contribute additional colors to the land. With all these different seasonal sceneries, Yangmingshan National Park attracts more than 12 million tourists each year.

Due to its latitude and elevation, Yangmingshan National Park has both subtropical and warm temperate climate zones, along with a very apparent monsoon season. This study utilized the Color Geography Theory of French scientist Jean-Philippe Lenclos to explore Yangmingshan National Park's color composition of natural and human geographical conditions, and used survey methods of color measurement recording, sampling, induction, spectrum compilation and summarization. The seasonal landscape's daily changes of natural light and shadow (such as dawn, morning, twilight, night, etc.) allow regional characteristics and colors to be recognized and used to illustrate Yangmingshan National Park's beauty as well as its environmental color image.

# Robustness of perceived glossiness scale using magnitude estimation method

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## Abstract

Nowadays, importance of the visual appearance quantification of a surface is growing. However, except color, other attributes such as gloss or texture are relatively less understood. In this study, perceived glossiness scale of a specular gloss is studied using magnitude estimation technique. The magnitude estimation method is one of the widely used psychophysical experiment method to scale color appearance attributes. Since the specular gloss has a similarity with the reflectance having minimum and maximum values, it is decided to use the same experimental technique for glossiness scaling with the lightness scaling.

Eleven black and eleven white polycarbonate samples with different levels of UV clear coating are prepared. The gloss values measured with BYK micro-gloss glossmeter varied from 3.88GU (@60 degree) to 93.89GU (@60 degree). CIELAB L* values for SPI mode are 94.3 and 26.6 for white and black respectively. Twelve observers judged the perceived glossiness in the viewing booth using three different methods i.e. judging one sample at a time, comparing three samples with the same color at a time, comparing four samples with different colors at a same time. In this study, perceived glossiness is treated as the intrinsic property of a surface, which is not influenced by illumination conditions or viewing geometry. Therefore, the observers were allowed to take hold of the samples for thorough examination and there was no restriction for body and eye movements. Also when observers were assessing the visual glossiness, no explanation or the definition about gloss is given. All the experiments were repeated twice. For the data analysis, the arithmetic mean is calculated for each simple.

The results show that the method presenting the glossy samples does not affect the perceived gloss significantly. It could mean that the gloss is an absolute characteristic of a surface not judged relative to other surfaces. Also it is found that the black sample's gloss is easier to judge than that of the white. The experimental results for black were more consistent regardless the experimental method compared to white samples. Finally, it is shown that black samples look glossier than white samples at all gloss levels.

# Creating a new world of colour and light by 21st century industrial designers

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## Abstract

"*Color can bring richness, beauty and ambiguity to design, if it is used well,*" said Hella Jongerius, a famous Dutch product designer. Colour planning in product design is a process which is crucial for a commercial success. Thanks to the development of new technologies an interaction of colour and light becomes more and more important in product design. New generation paints and light sources enable the changes of surface colours which do not have to be constant any more. LEDs which provide chromatic light with a very high saturation are universally used in devices which are not intended for lighting only. They can have communicative, informational, esthetic, marketing or ergonomic functions. Creating devices that enable customizing colours of our environment, like RGB lighting is no longer a science fiction. Customizing light and colour in our surroundings helps us to overcome a seasonal affective disorder. It is also quite common in graphical user interfaces, where giving a choice for a customer to choose colours according to his or her specific needs and desires is an essential element of a design. In contemporary design there has been also a growing interest in managing colour and light as communicational tools in product interfaces. The iconic language through a careful use of signs and colours enables a wide range of users an understanding how the product functions. Colour coding of emergency buttons and switches help people to act quickly in crisis situations. And chromatic light can draw attention to the most important elements of an object and may well be the fastest way to convey a simple message. Colour planning can be an important element of a brand strategy, allowing certain products to stand out on the market. Colour decision are also strongly influenced by short or long-term trends, colour forecasting, advertising and visual culture. Colour draws attention to products and gives them an extra value. That is a reason why light and colour can change an everyday product into a designers' item. On the other hand many designers are afraid of colours and rarely go beyond blacks, whites, grays and beiges for fear of making mistakes. There has been a long tradition of using neutrals in modern design and architecture, which even nowadays has many supporters.

This paper aims to present a range of products in which colour and light are treated in an unconventional manner. Among them there are pieces of furniture, household appliances, consumer electronics, lamps, vehicles, clothing, accessories and gadgets. A lot of them have been designed by famous industrial designers like Karim Rashid, Zaha Hadid, Marc Newson, Philippe Starck, Hussein Chalain, Yves Behar and Marcel Wanders. The other examples are works of industrial design students of Jan Matejko Academy of Fine Arts in Krakow.

# A prototype of goniophotoscope and its use

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## Abstract

Materials such as wood veneers and marquetry panels, patterned silk or metal fabrics, laces, stainless steel (expanded grids or welded/woven wire meshes for architecture), stained glasses… have directional visual properties (often with shadowing properties), which can't be researched only with hemispherical devices for bidirectional reflection or transmission distribution function (BRDF/BTDF) or goniospectrophotometers even with continuous orientation and incidence variation. The measuring area is too small (diameter is commonly from 1 to 14 millimetres) and spectrophotometry data can't meet the geometrical variations of a pattern due to the changing point of view: wide image also is necessary, hence the name of *goniophotoscope*. On the other hand, there are up to14 threads/millimetre in silk fabrics, and even an area of 1 square millimetre is not homogenous: close image also is necessary if we intend to understand what happens at the scale of threads or fibres. Moreover, it is necessary to put flexible materials into the right physical position, vertical or horizontal for instance, for mechanical reasons.

The resulting goniophotoscope is intended both for reflection and transmission, even simultaneously (as it happens in the evening, when natural light comes from outside and artificial light from inside), for distant or close photography or video, and goniospectrophotometry when necessary. The diameter of the table is 115 cm (suitable for 90 cm wide fabrics). It turns on three axes around its centre. A removable glass window (60 x 60 cm) allows back lighting. As a minimum for studying see through or translucent items, two light sources can be used, for front and back lighting, with spherical motions: 360° orientation (vertical axis) and quite ±180° incidence (horizontal axis). This gantry is suitable for direct visual examination, free use of any camera or video-camera independent from the device or in a removable support with variable incidence, for close pictures (or to be used with a spectrocolorimeter), or mounted instead of a light source when one is enough. Additional features allow investigations about shadows. The environment has to be set on specific requirements.

It allows easy cooperation between scientist and artist, designer, manufacturer, end user: properties of existing materials; reverse engineering; control of software for visual simulation; conception of new materials; specifications; control of properties of new materials which must match specifications; photographs and videos for commercial or advertising purpose; presentation of the visual effects of materials in the architectural environment of the end user, taking into account the orientation of sun due to the building, the hour, the season and the latitude, thus contributing to a diversification of architectural conception depending on climate, latitude, and cultural trends.

Now, we start the first motorized and computerized version. A wider cooperation should be useful for improving the specifications, for the software, as well as for research, artistic creation and innovative design. May we start a working group?

# The effect of color contrast between text and background on human comfort – psychological and physiological investigation

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## Abstract

Currently, people receive text information more through screen-based displays rather than via paper. As setting various text and background color combinations is easy on a screen-based display, the choice of a more suitable color combination psychologically and physiologically is necessary. In this study, we focused on the affective effect including both psychological and physiological response of color contrast between text and the background when humans read the text on a LED-based display. Two independent empirical studies were planned. The first experiment was to determine the proper brightness difference between the text and the background as people read text. There were 10 level of positive polarity stimuli and 10 levels of negative polarity stimuli. The second experiment was designed to investigate the human emotional response to different hues and combinations of text and background under the same brightness difference condition. There were 5 different hues (red, yellow, green, blue and black) that comprised the positive polarity stimuli with 80% brightness contrast, 5 different hues for the negative polarity stimuli, and 4 complementary color contrast stimuli. We recorded subjects' brainwaves while they were reading a given text for one minute for collecting physiological response and asked them about the cognitive as well as emotional quality of the text stimuli for collecting psychological response. The ratio of the alpha frequency (7.5~13Hz), the high-beta frequency (20~30Hz) and the ratio value of the alpha ratio/high-beta ratio was calculated. The alpha ratio was used for comfort level and the high-beta ratio was for the stress level. The results showed that the subject felt most comfortable when they read the text in dark gray (70%) against a white background. The subjects later read the text in chromatic colors and gave poor ratings to the text-background combinations of complementary colors. However, the subjects' physiological reaction, as measured by their brainwaves, did not vary across the chromatic text stimuli ($p > 0.05$). We can conclude that the brightness difference between text and background is more influential to people than hue difference. However, hue contrast affected physiological context intensely, so that designer should concern hue difference as well as brightness difference.

# Road safety sign color scheme for the color blindness

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## Abstract

The color-blind people have all kinds of trouble in their daily lives and the designers have certain responsibility for all the inconveniences and disadvantages that the color-blind people experience. Now the concept of the universal design is becoming common and all the designers should consider color-blind people when they plan colors An area of public design where the concept of universal design must be applied is 'road safety sign' because it is directly related to people's lives and safety. This paper, analyzes the color differences caused from the contrasting visions of the ordinary and color-blind people and the designers can utilize the suggested color schemes in the conclusion when planning colors for the color-blind people.

To compare how color-blind people perceive colors differently depending on ratio of each colors (Y, R, B, G), set Y, Y50R, R, R50B, B, B50G, G, G50Y as target colors and start simulation. To create specific color schemes for color-blind people, the analysis of the color difference compared to the ordinary people's sight was necessary. Road safety sign is a plate which conveys a message with picture or letters that indicates caution, restriction, direction and information to road users. By using colors, the road users can perceive the road signs easily and properly understand the meaning of them, therefore there is a need to decide which color function should be applied to road safety sign and which method to analyze color arrangements. If the colors have approximately 70 ΔEab color difference or more, the colors are considered suitable for the sign. Refer to the previously analyzed color selection guide to select the colors for color schemes and calculate the value of color difference to make sure the colors are suitable for the road safety sign.

As the result of analyzing color differences, we could find that even though there are big differences in value or chromaticness, arranging the same affiliated colors' value of color difference is less than other colors. Final result of analyzing color scheme is that arrangeing vivid RB affiliated colors with low value and high chromaticness is the most desirable. In this paper, we have presented a color scheme for the color planning of the road safety sign, which can be well perceived by the color-blind people.

By combining the NCS's color-blindness simulation and the color functions related to the road safety sign, it is concluded that the best color schemes are the combination of vivid RB affiliated colors and colors with low-value and high-chromaticness. In future, this research is expected to help the designers plan the color schemes of the road safety signs for color-blind people more easily based on the concept of universal design as well as enhancement the efficiency of the color scheme.

# Investigating the psychological and physiological effects of human exposure to color light

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## Abstract

Color lighting can influence mental and physical activity, however, past discussions have centered more on physical than psychological effects. People feel more comfort- able in a room of specific color lighting (Kruithof, 1941). Color temperature and illuminance induce different response of the autonomic nervous system as has been shown by measuring heart rate variability (Mukae & Sato, 1992). Color temperature of different ranges can also activate contingent negative variation (Deguchi & Sato, 1992). It was confirmed that color temperature and illuminance affect the central nervous system (Noguchi and Sakaguchi, 1996). Utilizing those findings, this research investigates how the color of room light influences people both psycho- logically and physically. An experiment was conducted to examine peoples' psychological and physio- logical response to lights of different chromaticity in a laboratory equipped with adjustable LED light (non-directional illumination) of 9 chromaticity settings (L, x, y) for red (12.2, 0.693, 0.304), green (11.9, 0.169, 0.686), and blue (12.3, 0.136, 0.590), yellow (11.6, 0.420, 0.502), cyan (12.2, 0.146, 0.227), magenta (12.0, 0.275, 0.120), white (52.6, 0.306, 0.312), gray (11.9, 0.304, 0.309), and black (0, 0.447, 0.368). Every participant was exposed to a lighting sequence of 9 colors for four minutes each. During each exposure, subjects were instructed to open their eyes during the first minute and then close them for another minute, repeatedly. The sequence of color exposures was conducted in randomized order. Bio-feedback receptors were measuring four modes of physical response: electrocardiogram (ECG), skin temperature (SKT), galvanic skin reflex (GSR), and electroencephalogram (EEG). After each color exposure, subjects gave their psychological response by sixteen bipolar semantic word pairs based on a seven-point-Likert scale: relaxed – agitated, feeling of lightness – feeling of heaviness, calm – excited, comfortable – uncomfortable, refreshed – gloomy, tired – vivid, cool – warm, sleepy – awake, sharpness of mind – dullness of mind, beautiful – ugly, soft – hard, elegant – vulgar, feminine – masculine, loud – discreet, pleasant – unpleasant, and like – dislike (Osgood, Suci, & Tannenbaum, 1957).

**Topic:** Psychology.

**Reference:**

Deguchi, T., & Sato, M. (1992). The effect of color temperature of lighting sources on mental activity level. *The Annals of Physiological Anthropology, 11*(1), 37-43.

Kruithof, A. A. (1941). Tubular luminescence lamps for general illumination. *Philips Technological Review, 6*(3), 65-73.

Mukae, H., & Sato, M. (1992). The effect of color temperature of lighting sources on the autonomic nervous functions. *The Annals of Physiological Anthropology, 11*(5), 533-538.

Osgood, C. E., Suci, G. J., & Tannenbaum, P. H. (1957 ). *The Measurement of Meaning*. Urbana: University of Illinois press.

# Using the camera as a paintbrush for non-photorealistic renderings (NPR)

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## Abstract

From the ultra-real to the surreal, from stillness to movements, the camera, digital or otherwise, is used as an image capturing device for photography (*phos*, Gk, light; *Graphis*, Gk, stylus or paintbrush) since 1861. Indeed, it is known as a process, an activity and expression using light as a medium based on a selected subject.

While camera records, light is color, visible or invisible to the human eyes. It establishes a complex relationship with its surroundings bodies and surfaces. In response to this interesting notion and sensibility, light source influences the result of the captured visage qualitatively. Over the years, some photographers have spent hours setting up, or rather "incubating" light to compose and achieve a desired effects over a chosen subject. Nevertheless, the camera remains as an enhanced recording device, as man directs the beam in the precise way accord in inhibited spaces – a rigidity that confines human exuberance.

As light source contributes to a phenomenon causing dispersion, light as a medium is formidable, it allows us to experience the dissolution of light whereby it attests the original meaning of photography. Upon investigations of hundreds of camera movement-directed camera paintings, this paper presents and demonstrates the possibilities and results of this intrinsic characteristics and capabilities of light by combining the hyper relation of camera movements and the light source. In which, this relationship depicts and expresses the nature or disposition of the hand gesture that determines, designs, choreographs and orientates light, thus produces non-photorealistic renderings (NPR), as manifested in "non-light" painting mediums such as pencil, charcoal, pastel, crayon, watercolor and oil. Depending on the speed and momentum of the camera movements, different compositions and textures can be captured instantly as a result of a click. The sum of movements of this camera offers infinite generative in-camera paintings without any post-possessing. Based on this phenomenon, non-photorealistic renderings can be composed independent of the subject matter, the motion of the subject, the lighting conditions measured by distance between the camera person and the subject, cumulative luminosity of the various light source. Basically, creating a composition anytime, anywhere. It reinforces the notion of light is color. As such, this lighting performance ensues a new aesthetic experience being established with innovative potentials. The assembly of movements that transforms the spatial experience of light defines a new portrait and a new identity of light – a new semantic of light. The multiplicity of light is only a distance away from our thoughts, appropriating us in experiencing light in an unprecedented way.

# Experimental evidence for the formula for saturation

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## Abstract

In 2007 the author proposed a new formula for the saturation.

The formula proposed by the author is in agreement with the verbal definition of Manfred Richter: Saturation is the proportion of pure chromatic colour in the total colour sensation.

$$S^+ = \frac{C}{\sqrt{L^2 + C^2}} \, 100\,\%$$

For the experimental verification we need visual scaling data of saturation assessed by subjects. Because good scaling data could not be found in the literature a new investigation has been accomplished. For this the Japanese colour system PCCS has been used. For each hue there are 14 saturation steps. Therefore, each subject had to position $12 * 14 = 168$ colour charts on a given scaling area.

At first the people who have to scale were introduced between the difference between chroma and saturation.

For visual scaling lines were drawn on a middle grey background. So we get a scale from 0 to 100 % from the left to the right. On the top left we put the white chart as 0 %. This is the zero point of the scale. Under the white chart we place some grey and at least the black chart. The person now has to put the charts of the first hue on the grey paper. He has to imagine that it is possible we can have charts with more saturation as the charts in his hand. That means that the chart with the highest value of saturation is probably to be placed on a point under 100 %. The next step is that he puts charts with white in the colour on the scale. This was easy to do for the most people. Finally the charts with grey and black have to be put on the scale. This was not easy in all cases.

After putting all charts of the first hue on the grey scale, we look on which lines they lay and write down the values in a table. Only the first chart of the first hue stays on the scaling paper and the test person makes the same with the next hue and so one.

The visual test was done after ISO 3664 for graphic industry with daylight D50 and 2000 lux.

The experiment shows that the proposed formula can be used for calculating saturation from the measured values $C_{ab}$ and L*.

If we make a new space with the axes L, $S^+$ and h we get a nearly symmetrical space.
It is much more symmetrically than the LCh-space.

The LS$^+$h colours space is an interest space also for calculating colour differences.

To have a formula to calculate saturation is useful for designers.

# Colour harmony for fashion design

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## Abstract

Conventional studies of colour harmony have relied on the use of colour patches as the stimuli in an attempt to simplify experimental conditions. Such settings have led to question marks, however, as to whether or not the findings can apply to real world applications. Fashion design is an area where colour is seen as a crucial design element. It is essential for fashion designer to ensure each colour scheme looks harmonious and thus appealing to the buyer. By looking into the harmony response for fashion designs, the present study attempted to address the context issue for colour harmony.

Thirty-six observers participated in this study, including 20 Chinese and 16 British, each assessing colour harmony of 90 fashion images, presented on a calibrated cathode ray tube display, using force-choice 10-point categorical judgement method. The 90 images consisted of three fashion styles, spring, summer and winter, each containing the same set of 30 colour schemes. The experimental results show that while fashion style and colour scheme both have a significant impact on harmony response, the two factors may be independent of each other. The results also demonstrate that the high-chroma fashion images were seen as more harmonious than those with low chroma values, whereas the opposite trend was found for colour patches.

# The choice of colours in graphic design in relation to the children's preference. Aspects transferred to the colour appearance of printed media

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## Abstract

The aim of this paper is directed at the observation of colour preference of children to the printed media products.

It is well known that extensive studies have been done on colour appearance. Some of these studies deal with the emotional effects of colour on people in general. The others show which colours children are attracted to in relation to those which adults are attracted to. Based on these facts two objectives of this paper have been defined. The first one is directed at the choice of colours for different kinds of children products: picture books, birthday invitation cards and toy catalogues. It is based on the fact that the choice of colour used for children printed media toys belongs to the graphic designer (adult) and that the chosen colour is the result of his creativity and knowledge of children psychology. The second objective is based on the fact that children colour preference may differ according to their nature, temper, different lightening and atmospheres during the daylight.

The same methods were used for detecting the preference of colours of adults (designers) and of children. Three different graphics were used in the study and each was coloured in different background: blue, red and yellow. The graphics were held up for five seconds and the interviewees were asked about their preference. Only five seconds were allowed for the viewing of the graphic because a quick glance is aimed at provoking purely emotional reactions. The children and the designer had to decide which graphic and background they prefer according to the presented printed media. The children were asked those questions in the morning by early daylight, in the noon and in the afternoon. The test was repeated a few times and throughout few days to get more concrete results.

The results of the paper include: analysis of mostly used colours in design of printed media products; children preference of used colours for specific purposes; analysis of children preference of colours in different light surroundings. The results have shown that designers' choice of colour is in correlation with the main children preferences. One can say that designers thought that girls prefer red and yellow, and boys prefer blue. On the other hand, the results have shown that there were no particular differences between boys' and girls' preference of presented colours or graphics. Exposure to different light surroundings showed that in the afternoon children chose blue rather than warm colours.

This paper has given new findings about the influence of atmosphere and daylight conditions on colour preferences of children. It has given an interesting perspective for graphic designers that are involved with children printed media industry.

# Comparative analysis of electrophotographic prints with the standard magenta and cyan in relation to the prints in which light magenta and light cyan are added

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## Abstract

The achieving true to life reproduction of the original is the main task of the printing process. By adding the light process inks (light magenta, light cyan) the more uniform printed tones are achieved, which results in the print of photographic quality. Except the Ink Jet printing, some electrophotographic units (satellite construction) can print seven colours. Very often the light process inks. The aim of this work is to find out which reproduction can be achieved with the addition of the light inks and which difference appears in relation to the standard electrophotographic print; and to determine by the microscopic analysis of prints how the RIP is generated by the intermediate tones, as well as to see if there is any possibility of additional regulation of cyan and magenta tone reproduction. This enables the further analysis of the printing process, i.e. it gives the answer how the variation of the voltage of the developer roller BID and the variation of the power of laser diodes improves the print quality in relation to the possible printing substrate.

In this work the spectrophotometric analysis (X-rite DTP 20 with the measuring geometry of the optics 0/45°) of standard magenta and cyan prints has been done (4 colour print) in relation to the 6 colour print (the added light cyan and light magenta). With it the continuous wedge is reproduced, containing 9 screen patches (in the range from 10% to 90% in steps of 10%). For the analysis of the printed patches, first were obtained L*a*b* values. The inking difference (CIE LAB $\Delta E_{2000}$) was calculated from these values. After that the image analysis of the samples was performed where the dimension of the reproduced screen elements ($\Delta d$) was measured from the magnified images (Personal IAS magnified 10x). Because of the different coverage some diameters were especially noticeable: the diameters of the screen elements, diameters of the dark screen elements and the diameters of the white light screen elements (the unprinted areas). For the analysis the open source software Image J 1.72q

The addition of lighter inks in the screen reproduction does not achieve considerable visual changes in tone ($\Delta E_{max}$=3,00). But they are more expressed in magenta $\Delta E_{mean}$=2,16 in relation to cyan $\Delta E_{mean}$=1.18. On prints, the light screen elements are applied up to 40% of screen value, after which they change into the full tone. Medium and dark areas contain 100% of the applied light ink to which the screen elements of the darker inks are added. With it the diameters of the screen elements range from 56,5 μm up to 96,02 μm, while the diameters of the dark screen elements range from 37,64 μm up to 135,91 μm.

# Color modification of signboard suitable for streetscapes without significant loss of visibility and logo identity

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## Abstract

Two experiments were carried out to determine signboard color modification rules for a harmonized streetscape in which signboards are visible and the identity of logos is clear.

The first experiment dealt with logos on signboards. A total of 186 samples (14 unsuitable samples were removed from the 200 samples obtained by considering all combinations of ten color patterns and twenty logos were displayed on a screen by using a liquid crystal projector. In the second experiment, signboards with logos displayed in the first experiment were introduced in three streetscapes—a traditional street of Japan, a street in a commercial district, and a green street in a suburb. Twenty-two women students rated their impression of each sample using eight 7-step semantic differential scales on each experiment.

Three factors are identified by factor analysis (principal component solution, varimax rotation) of the mean values of the ratings from the experiment 1. They are preference, visibility, and warmth. The scale 'Similarity to the original logo' has a comparative large coefficient for factor 1, preference.

Modification patterns that retain the original colors show relatively higher values. This result suggests the importance of retaining a logo's hue.

Three factors—composedness, visibility, and warmth—are derived by factor analysis of the mean values of the ratings from the experiment 2. Preference is a complex factor of factors 1 and 2. This is the main difference in comparison to experiment 1, and it suggests the availability of color modification rules that make the signboard harmonious with the streetscape, and visible.

Highly composed and visible feelings were obtained for the original patterns and for low background brightness, small difference between the brightness and saturation of the logo and the background colors, overall low saturation, exchange between figure color and background color, red and white combination in the case where the original logo colors are warm colors, etc.

The experimental results suggest that three types of color modifications can be used in a signboard to provide composedness to a streetscape and for high visibility of a signboard. They are tone change with retention of the original hue, exchange between figure color and background color, and the use of a red-white color combination in cases where the original logo colors are warm colors.

# Representation of texture and interreflection using spherical mirror for mixed reality

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## Abstract

Representation of texture and interreflection to keep optical consistency between the real environment and virtual objects is important in Mixed Reality (MR). This paper proposes a real-time representation method of interreflection using spherical mirror. The proposed method is capable of rendering reflected real environment onto virtual objects using Sphere Mapping that is one of methods of environment mapping. Then the method represents local interreflection onto the virtual object by blending the color of the object with color in image of spherical mirror while changing the ratio of each color. Moreover the method represents surface roughness by means of changing the resolution of image of spherical mirror. This paper uses Torrance-Sparrow reflection model that is one of Bidirectional Reflectance Distribution Function (BRDF) in order to represent material properties of a virtual object.

Material property of a virtual object depends on the appearance of gloss on the object. If gloss is strong, we feel the object has smooth surface. An appearance of local interreflection on an object is also affected by gloss. So the proposed method represents the local interreflection onto the virtual object by blending the color of the virtual object with color in image of spherical mirror based on the ratio $\alpha$ of the diffuse reflectance and specular reflectance of the virtual object. When the ratio $\alpha$ is 1.0, strong gloss appears on the object. Then it looks like a metal. When the ratio $\alpha$ is 0.0, gloss doesn't appear on the object. So it looks like a mat ceramic. The results show the proposed method can represent different material properties by controlling the ratio $\alpha$.

The spread of specular reflection that shows surface roughness can be described by parameter $\sigma$ of Torrance-Sparrow reflection model. To represent surface roughness of a virtual object, the several spreads of specular reflection are simulated for a sphere while changing the parameter $\sigma$. Then an area that shows the spread of specular reflection in the simulated image is extracted, and mask image for conversion of the resolution of image is prepared. When we represent a virtual object with arbitrary surface property, the image of spherical mirror is blurred by this mask image that matches the surface property.

The interactive application with combination of the proposed methods can display MR representation with low computation cost.

# Contribution of colour and texture information to the recognition of natural objects

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## Abstract

When we recognize a natural object, we use the memories of various visual attributes, i.e. shape, colour, and texture etc. However it is unclear how these attributes interact to each other. We memorize the colour of the natural object and the memorized colour is named memory colour. Memory colour tends to be shifted to a higher saturation than colour of real natural objects (Bartleson 1960). Previous studies for memory colour used uniformly-coloured patches for the stimuli (e.g. Pérez-Carpinell et al 1998), and the interaction between texture and memory colour has not been investigated. In this study, we investigated whether texture information of a natural object has an influence on memory colour or not. There are three possibilities for the influence of texture information on memory colour. The first possibility is that the colour gamut that is plausible as the colour of a certain natural object is wider when the coloured texture patches is observed. The second possibility is that the colour gamut that is plausible as the colour of a certain natural object is smaller with texture information than without texture information. Finally, there is the possibility that memory colour and texture information are independent each other. In this case, even though a texture is added to chromatic information, the colour gamut would not change. We examined which hypothesis of the three is appropriate.

We prepared uniformly-coloured patches and coloured textured patches as stimuli. The texture information of coloured textured patches was obtained from the image of the surface of a cabbage or a watermelon taken by a digital camera under a D65 illumination. We measured the plausibility of stimulus colour as a surface colour of a cabbage or a watermelon. Observers evaluated the plausibility of the presented colours by using four grades: very similar, similar, different, and very different.

As for the cabbage, the results showed that the plausible colour for the coloured textured patch had lower saturation than that for the uniformly-coloured patch. However, as for the watermelon, although the saturation of the most plausible colour was not different between the coloured textured patch and the uniformly-coloured patch, the colour gamut which provided high plausibility evaluations was slightly smaller for the coloured texture patch than for the uniformly-coloured patch. These results suggest that texture information makes the colour gamut small, and it is clear that texture information influence memory colour.

# PERCIFAL method in use: Visual evaluation of three spaces

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## Abstract

The PERCIFAL project aims at developing an evaluation method that captures the overall visual experience of architectural space in a form that can be compared and analyzed later on. The background and the methodology of the PERCIFAL method are to be presented at AIC 2011 in a separate paper by Senior Lecturer Harald Arnkill et al. In this paper we describe the use of PERCIFAL method for visual registration and evaluation of three architectural spaces in Trondheim, Norway. The spaces were chosen to represent significantly different room shape, (day)lighting and colour design. They are named: 1. Atrium, 2. Skylight Room, 3. Electric light room.

The Atrium (glazed courtyard) is a part of the hotel building situated in Trondheim Centrum. The atrium is nearly square in plan (11 x 12m) and has a height of 5 storeys. It functions as a secondary daylight source for apartment rooms adjacent to it. The atrium is also characterized by a strident colour composition with strong luminance and colour contrasts on walls and floor. The Skylight Room is the largest and the most spectacular room in Kunstmuseum, the Art Museum in Trondheim. There is a linear, large and elegantly designed skylight in the room that nearly dominates the visual environment in the room. The Electrical light room is a part of the exhibition area in the Nordenfieldske Kunstindustrimuseum, a museum of applied arts in Trondheim. The room has some high and narrow windows that are covered by rolled and sun-proof blinds. The room is lit by an electrical lighting system composed of halogen spots. A considerably large group of subjects visited those three rooms in August 2010. They were asked to make a spontaneous verbal evaluation as well as evaluation with the help of quality descriptor differentials developed in the PERCIFAL project, as: light level, light distribution, shadows and flecks of light etc. The participants were: master students of architecture (15 subjects), a group of electrical engineers' (13 subjects) and two architects. During the same visit the illuminance was measured in a few places in the room and colour sample matching was carried out. Additionally, some photographs were taken. Despite differences between subjects, it was possible to find e.g. a strong correlation between surface illuminances, the score at Light Level scale and the impression of openness/spaciousness versus darkness/gloominess. Furthermore, it was possible to find a correlation between the occurrence/absence of chromatic colors in the room and the impression of the room being serious and stringent versus lively and playful. The skylight room, which has the gray-scale color composition, was evaluated as the most stringent of all; the atrium, which had a red carped on the floor and colored glass panes on the roof was evaluated as the most playful and lively one.

# Interaction between colour and light
# … and different spaces
# … and materials
# … and sound/composition/music

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## Abstract

The organism of our senses reacts to impulse of light and colour and sound and its permanent changes. Our brain processes this stimulus independently and individual. That's the same for all of us. I notice a huge variety of colour and light in nature exactly – and I have transferred it into my artist-language, realised in colour-light-concerts, architecture, art, urban projects and material development.

Each of us is able to differentiate about 165 single sense-perceptions in one second. It is an individual process and cultural stamp, which one we record. Light, colour and sound have one common parameter: time. Here it is on our mind, which we store. We can save them – and we can recall, if we want. In my 'light-sound-concerts' I have created interactions for light, colour, sound and space. Their combination works and our senses are in the present, NOW. People only can see and listen. We artists are working interactive and analogue – we are invisible for the audience. I made my experiences with variant sounds in several environments. Each space, each material needs special adaptation. I only complete with material of my atelier: my 'Farbglas', which lights up by itself, the 'Kubus', which works like a symbol for context with the cosmos and with special textile material, tense like ray for the light.

The environment seems to change itself permanently – shape, color, time becomes new dimensions. Sometimes the architecture disintegrates itself, light focuses or leads the view. Light builds up atmospheres and lets associations grow up, or visions of nature develop from abstract views, which are a result of calculated sounds. Sometimes: only single colours, sometimes interaction of all: space, music, light, colours, movement and rhythm. The experience of the concert moves us back into ourselves, to our own soul. Knowledge and perception merge, new ideas are stimulated. Posture and breathing are influenced. Worldwide I have found some twins of notes and colours, which people associate equally. Those people, who trust in universal principle of permanent change and effect of senses, will always find out new connections. Interaction of colour, light and sound for such a special concert is based on an individual composition. People get experiences with their own perception on senses and brain. Physis and psyche react. The concert-contents seem to work very individual – but lots of parameters are the same for people worldwide. My way to find out more about those phenomena is, to learn permanently while doing and comparing with the knowledge of different fields of research. The more senses are opened for perception of the 'stories' of light and colour, sound and space, the more we can understand the connections with the rules of universe and can take care about them. My engagement is, to give my attention to both of them: science and perception. The 'colour-sound-concerts' are my artist-contribution.

# Development of plug-in for optimizing colours of graphic and web designs for persons with dichromatic vision deficiencies

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## Abstract

In our daily lives, use of colour is increasingly becoming an important means of information transmission in print and e-media. While these colour information are taken for granted by a majority of readers and viewers, people with colour vision deficiency have difficulty in discriminating certain colour combinations that are easy distinguishable to people with normal colour vision, and, as a consequence, they have difficulties in recognizing and perceiving information.

The purpose of this study is development of plug-in, which simulates dichromatic forms of colour vision deficiency, in consideration with the actual viewing conditions (illuminant and luminance level) in order to enable graphic and web designers to check how will their work look to "colour-blind" people in different types of viewing environment. The algorithm of plug-in, written for Adobe Photoshop and other compatible graphic software using the Filter Meister development environment, is based on the transformations of the CIECAM02 colour appearance model, and widely accepted dichomacy simulation method described by Brettel et al. The accuracy of plug-in algorithm is evaluated by eight registered dichromatic persons, who were comparing simulation results of colour charts on monitor and colour charts viewed in light box in controlled conditions (illuminants: D65, D50, F11 and A). They perceived negligibly little or no colour differences between original and simulated images, which confirm reliability of Brettel's algorithm implemented with the CIECAM02 model. The other conclusion deducted from the analysis of simulated images and confirmed with dichromats' observations is that decreasing in temperature colour of illuminant leads to even more reduced colour gamut of dichromats and, thus, to enhanced number of hardly distinguishable colour combinations.

The other important aim of this developed plug-in is image processing which results in increased number of distinctive hues that people with certain type of dichromacy can perceive, without significant reducing aesthetical attractiveness and naturalness of the image for 'normal' viewers. The selectively image processing is accomplished by changing the hue and saturation values of problematic colour combinations in order to obtain new colour schema which will be optimal for both normal and dichromatic viewers. Based on dichromats' observations, the image re-colouring gives positive results.

The developed plug-in allows creation of user-oriented design so that information can be accurately conveyed to as many individuals as possible.

# Sensitivity evaluation study of LED lighting colors based on natural light

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## Abstract

The development of lighting source till now has been focusing on the high performance and function; however, now there is strong awareness that the lighting products should be developed from user's perspective reflecting the physiological and psychological of people. This study suggests the LED lighting colors based on the natural light which gives absolute impact on people. The study will evaluate the sensitivity response by analyzing and exploring the characteristics of people's sensitivity who respond to the LED lighting colors.

This study extracted the LED lighting colors based on natural light and used analysis method of questionnaire survey. LED lightings consisting of five lighting sources (Red, Green, Blue, Warm white and Cool white) were used to simulate natural light by bare-eye method and their values were extracted. The LED lighting colors extracted from natural light were displayed on a LED Light box and the sensitivity responses were collected and analyzed by questionnaire survey. In the sensitivity adjective evaluation, adjectives related to space were investigated and analyzed. Semantic Differential method (SD method) was used for the evaluation. Regarding the preference survey, subjects were asked to rank four preferred colors and the remaining four colors were regarded as not-preferred colors.

The results of sensitivity response of LED lighting colors based on natural light suggested that the color temperatures between 5000-5500K and the brightness values between 2500-3500cd/m$^2$ were evaluated high in the sensitivity adjectives analysis. In the preference analysis, the color temperatures of 5500K and the brightness values between 2500-3000cd/m$^2$ were highly preferred. Therefore, it is believed that there is a relationship between the sensitivity adjectives and the preference. In addition, it is believed that there is positive sensitivity response at the color temperature of 5500K and brightness value in 2500-3000cd/m$^2$ range. The results suggest that there is certain range of preferred color temperature and brightness value and people's preference does not change as the natural light changes continuously. It was possible to confirm that the LED lighting colors give impact on the sensitivity response through this study. It is believed that continuous studies on LED lighting colors would be required so that more color characteristic analysis would widen the width of understanding on user sensitivity.

# Classification of fragrances by their similar psychological images with colors (2) - development of a law describing the harmony between fragrances and colors with special emphasis on the tones

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## Abstract

The purpose of this study is to extract dimensions in impressions of fragrance and color based on their impressions, and to examine the relationship between their harmony with special emphasis on the tone. Experiment A: We studied how individuals associate fragrance with color. One hundred subjects were randomly assigned eight fragrances (cinnamon, peppermint, vanilla, rosemary, lemon, anise, pepper, and rose), and were requested to describe the impression (SD method) of fragrances. In addition, the subjects were asked to select, two sets of three colors each from color charts consisting of 18 colors (3 tones [pale, vivid and dark] each from 5 hues[red, yellow, green, blue and purple] and 3 achromatic colors [white, gray and black]), such that one set matched a fragrance, and the other did not. Experiment B: We examined how individuals associate color with fragrance. One hundred subjects were randomly assigned 18 colors and asked to describe the impression. In addition, the subjects were asked to describe the degree of match for each of the 8 fragrances with the 18 colors. Experiment C: We added fragrances and a similar experiment to Experiment A was done. The fragrance was increased to 120 and a total of 220 volunteers participated in the experiment.

We conducted factor analysis and derived *mild* factor consisted of "sweet-not sweet", and "feminine-manly", and *clear* factor consisted of "clear-muddy" and "bright-dark" for dimensions in impressions of each fragrance (Experiment A), color (Experiment B), along with fragrance and color together (A and B, and B and C). Reviewing the factor scores, we can note that the *mild* is correlated with the warmth/coldness of the hue and "sweetness" of fragrance. On the other hand, the *clear* can correspond to the tone of color and "clarity" of fragrance. By the multiple regression analysis, we derived the following tendency: With respect to the dimensions, the lesser the distance between fragrance and color, the greater is the rise in harmony; conversely, the greater the distance, the greater is the disharmony. Thus, harmony is created based on the similarity of the impression. We also conducted cluster analysis and obtained following eight groups: [*spicy & herbal*]; [*minty* & pB, vB]; [*cinnamon*]; [*flower* & vR, vY, vG]; [dkB, Gy and Bk]; [*woody* & vP, dkR, dkY, dkG, dkP]; [*citrus* & W]; [*sweet* & pR, pY, pG, pP]. In addition, For *woody*, dark tone was matched, and pale tone was mismatched. For *citrus* and *sweet*, pale tone was matched, and dark tone was mismatched. The *clear* factor is an axis that determines whether a color is "pale" or "dark", and it showed the tendency that "pale" harmonize with the fragrance of the high score on *clear* factor, while "dark" harmonize with the fragrance of the low score on the *clear*. Therefore, tone thought to be important factor for harmony with fragrance.

# Influence of the frequency of an achromatic grating with the Bezold effect caused by a rectangular interleaved sequence inside

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## Abstract

In the School of Design Engineering at the Polytechnic University of Valencia have been studied for 10 years chromatic expansion (Bezold effect) produced by Ronchi gratings (achromatic and monochromatic rectangular sequence interleaved inside), presenting their results in various national and international congress, we cite as examples the last presented at the IX National Congress of Color in Alicante 2010: "Visual perception of a rectangular sequence seen through an achromatic contrast unit grating", and the Interim Meeting of the International Color Association, AIC 2010 in Mar del Plata (Argentina): "Effect of chromatic Assimilation (Bezold effect) in the vision of the content in a dinner plate."

We study the relationship between the frequency of an achromatic (contrast=1) Ronchi grating (vertically or horizontally oriented) and color expansion (Bezold effect) produced in a blue rectangular interleaved sequence within it.

We followed the same experimental technique and worked with the same observers who assessed the relationship between a monochomatic grating (white-blue) and a gray rectangular test ($\beta = 0.5$) in the work of Alicante, what allows us to relate current results with those obtained in the work mentioned.

The test used is composed of three parallel straight lines (width equal to their separation, 1 cm), the background sequences that have a grating with a 2 cm period, covering a circle of 20 cm in diameter. This circle is circumscribed by a square. The grating is presented in two orientations (vertical, vertical stripes and horizontal, horizontal stripes) and color (blue), with the stripes perpendicular to the grating. Gratings and sequences are generated and printed by computer.

The small superiority of the color expansion (Bezold effect) produced by the monochromatic grating over the achromatic grating, is because the thresholds in the vision of the hue are smaller than the clarities (variations obtained with achromatic gratings). Changes in perceptual vision of the sequence (Bezold effect) is less than the latest gratings mentioned, which is to say that the Bezold effect is smaller.

Results tells us that the Bezold effect produced is much higher in the horizontal orientation of the grating in both gratings: achromatic and monochromatic.

There is a clearly proportionality between the frequency of the grating and the Bezold effect produced in the interleaved sequence.

# Ontological approach to a structure of color emotion: Descriptions of relationships among rating scales

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## Abstract

From a viewpoint of knowledge engineering, it is an important task to clarify concepts of color emotions. One effective method to achieve the task is to construct an *ontology*. On a basis of the ontological description, knowledge of the target world is represented as an instance which indicates a knowledge description actually used in computer-based systems. In this paper, we described the knowledge of color emotions through construction of an ontology and their *instances*.

We specified basic concepts relating to rating scales and their instances, using the development environment Hozo and YAMATO (Yet Another More Advanced Top-level Ontology). Color attributes were specified as the qualities of object, and color emotions are specified as the qualities of feeling or sensation. Some rating scales are not necessarily characterized by a single basic concept. For example, a descriptive scale can be ontologically linked with a factor of feelings as well as with factors of sensations.

To verify whether or not the descriptive scales can be actually characterized by a factor of feelings, we conducted visual experiments. Eight undergraduates were served as subjects, and were asked to assess fifteen color stimuli with the twelve seven-point descriptive scales (light-dark, soft-hard, warm-cool, turbid-transparent, deep-pale, vague-distinct, heavy-light, vivid-sombre, strong-weak, passive-dynamic, gaudy-plain, striking-subdued) and another twelve scales for each descriptive scale with a seven-point scale of "pleasure-unpleasure". The fifteen color stimuli were provided by combining three hues (red, green, blue) and five tones (dark, deep, vivid, brilliant, light). A correlation analysis was conducted and yielded significant results between values of the "pleasure-unpleasure" scale and each value of the descriptive scales (r = -0.59* in light-dark, r = -0.66** in soft-hard, r = -0.78*** in warm-cool, r = 0.74** in turbid-transparent, r = 0.70** heavy-light and r = -0.73** in vivid-sombre).

Our experimental validation for the descriptions proves that some descriptive scales also have linkages to pleasure-unpleasure scale. This indicates a possibility that both scales of evaluative and descriptive dimensions can be described by only a few common basic concepts. For the aspect of applications of color research, the ontological descriptions proposed in our study will promote implementation of knowledge about color emotion in computer-based systems.

# Chromatic characterization of urban fragments: Validation of a user-oriented protocol through the study of Hors-Château street (Liège, Belgium)

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## Abstract

A growing need for objective assessment of colour has been observed in recent years in the field of urban design. In contrast to other building attributes (shape, size or location), which are easy to specify, urban design codes generally define expected chromatic attributes of building façades through indirect regulations considering materials. Some municipalities propose colour charts as guidance tools for urban regulation which present some disadvantages. This obvious lack of affordable instruments in a purpose of characterization or regulation was the main motivation of this research.

The aim of this paper is to present a user-oriented protocol which can be applied to characterize chromatic attributes of an urban fragment. The challenge is to provide quantitative answers to these two questions: how is colour organized, how does it develop a structure in the city? The main purpose of the research is hence to investigate stable colour typologies within the city; each urban area (historic center, suburban housing district, commercial zone, etc.) being characterized by a specific colour palette.

The method has been intentionally based on widespread use tools – digital camera and image processing software, like Gimp or Adobe Photoshop – so as to make it affordable to potential end-users like municipalities or urban planners. A rigourous measurement protocol was hence established for collecting colour samples, setting weather conditions, lighting and photo shooting. In order to maintain consistency in the comparison between different urban fragments, it is necessary to define stable outdoor lighting conditions: solar geometry and weather conditions could indeed disturb the spectral distribution and intensity of illumination, which would cause variations in the colour rendering of materials. Moreover, choosing an appropriate colour space for the method and the type of data representation is critical to a user-oriented interpretation of chromatic distributions. The (H,S,L) colour space has been adopted as its relevance from the point of view of perception is higher than that of the cartesian representation of the (R,G,B) colour space.

The proposed protocol has been first applied to Hors-Château street in the historic center of Liège. It adequately reveals quite a large distribution along the [355°-10°] directions in the (H,S) circle, due to the use of red clay bricks in this street. Secondly, a peak of saturation appears in the red area, which can be explained by the use of scarlet red coating, a colour often used in Liège for the renovation of listed buildings. Finally, some values appear in the blue area, due to the use of blue stone for some buildings.

# Influence of color scales and subjective color impressions in the development of architectural projects

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## Abstract

The evaluation of color differences and tolerances is an important issue in industry and arts. In addition the color has a significant impact on the overall perception of an urban environment because any object introduced into the environment becomes a visual target in relation to its context. We have developed a psychophysical experiment for testing the influence of color in those kinds of projects. The main building properties analyzed were the length, the size and the depth cues. A real architectural project was used as a standard reference to design a psychophysical experiment with naïve and non-naïve observers (all color normal as assessed by the Ishihara test). A discriminative threshold, which represents the smallest difference between two stimuli that can be detected, was used.

Results show that the most relevant cue was the height and not the weight as expected. The distance cue evoked similar answers for all the colors used in the experiment and suggests that this is the most familiar factor for the observers. The color cue influences weight and height, with the achromatic black being the most relevant as opposed to the white color. The influence of the white and the yellow colors on the height was also clear. It seems that the influence of color in the perception of the architectural project depends clearly on the color used in the façade (e.g. 'bright colors' induce overall 'bright perception'). The colors labeled as white, yellow and green according to that model were the brightest colors used in this experiment, with the more saturated ones being the red and the blue colors. Some kind of correlation between perception of colors and final perceived impression in the architectural project was found, which was also confirmed by analysis of variance tests. Statistical results and illustrative plots of the observers' answers will be included in the final version of the work.

# Construction of simulation for Kansei evaluation of colors by using linked multiple neural networks

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## Abstract

This study aims to examine the feasibility of the kansei evaluation by using a computer with a neural network. Before now, various features were given to the neural network, but the weight of each connection from input layer was biased and the error exceeded 5%. Therefore, after the authors reconsidered human kansei information processing, it found that human kansei information processing were composed of the processing from sensation (visual sensation) to perception and the processing from perception to cognition. According to this consideration, the authors try to divide these processing layers in order to make up the neural network suitable for human kansei information processing model. That is to say, two neural networks are used, one of them assumes the role of the processing between sensation and perception and the other assumes the role of the processing between perception and cognition. Eventually, the bias of the weight from input layer and the error for each neural network are expected to be improved, and then these neural networks will be linked.

In this study, the evaluation experiment is conducted by human subjects and the neural networks learn the data collected from human subjects. In the evaluation experiment, 30 images that have sixteen-color squares in a 4 x 4 square are presented to human subjects, they evaluate 11 pairs of adjectives for each image and their eye motion is measured as one of the information from sensation to perception. 11 pairs of adjectives consist of 6 of them for evaluation at the perception layer and 5 of them for evaluation at the cognition layer. Then, two neural networks learn the data collected by the evaluation experiment. At the layer model from sensation to perception, hue, lightness, saturation and gaze time ratio of each of sixteen colors are given as input data, and 6 pairs of adjectives for perception layer are given as output data. At the layer model from perception to cognition, 6 pairs of adjectives for perception layer are given as input data and 5 pairs of adjectives for cognition layer are given as output data. As a result, gaze time for each colors has bias of the weight of input layer, the errors of both the layer model from sensation to perception and the layer model from perception to cognition improve to 0.04% and 4.5%, respectively. That is to say, gaze time affects the weight of input layer and the learning efficiency for the error ratio are improved by using these models, especially at the layer model from sensation to perception.

Consequently, the error ratio of the layer model from perception to cognition is still high. Therefore, the authors have to consider how it can be reduced. After reconsidering and solving this issue, two neural networks will be linked and the accuracy of evaluation results will be compared to the ones of human subjects.

# The evaluation of dichromatic simulation by a visual search task

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## Abstract

Dichromatic simulations (Brettel et al 1997) of natural scenes are used widely in social and educational environments. However, whether the simulations really reflect dichromatic colour vision or not has not been examined scientifically yet. Thus we evaluated the validity of dichromatic simulation by using a visual search task. We measured reaction times (RTs) to detecting a particular colour, i.e. a target colour, in an unsimulated stimulus (an original stimulus) for anomalous trichromats and simulated stimuli for normal trichromats, and compared these RTs.

The stimulus consisted of 13 coloured disks (one target and 12 distractors) which were arranged in a circle. The colours of the disks were chosen from 24 colours defined in the CIE1976u'v'UCS diagram. Those colours were in a constant distance of 0.06 from the D65 chromaticity, that is, equalled in saturation and luminance (8.0 cd/m$^2$) but differed in hue. The target colour was one of the 24 colours, and assigned to one of the 13 disks. Two colours, which were ±45 degrees in the hue angle relative to the target colour, were used as distractor colours. Each colour was assigned to six distractors. The background coloured uniformly with the D65 chromaticity grey (the luminance was 4.0 cd/m$^2$). The simulated stimuli were produced by transforming the original stimulus by the algorithm of Brettel et al (1997). Six trichromats and three severely anomalous trichromats (one protanomalous and two deuteranomalous) participated in this experiment. Their task was to detect the target colour assigned to only one disk as soon as possible. The observer was also instructed to respond the position of the target colour.

Comparing the RTs for the trichromatic observers in the original condition with those for the anomalous trichromatic observers, although the RTs for the anomalous trichromatic observers tended to be longer than those for the trichromatic observers, the anomalous trichromatic observers could find more efficiently a target colour than the trichromatic observers on a particular colour combination. The RTs of the simulated colour stimulus for the trichromatic observer were qualitatively similar to those of the original colour stimulus for anomalous trichromatic observers. However, the RTs of the anomalous trichromatic observers tended to be longer than those of the normal trichromatic observers in the colour combinations. This tendency was most remarkable in the deuteranopic simulated stimulus. Thus there is a possibility that the simulation by Brettel et al (1997) overestimates dichromats' colour detections. We conclude that the dichromatic simulation does not always agree with real dichromatic people's colour perception, and that it is necessary to modify the dichromatic simulation, e.g. to reduce the chromatic contrast in order to increase the difficulty of colour detection

# Survey of the exterior colors of the academic buildings – in the center of Kansai

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## Abstract

Nowadays, with the aim of creating aesthetically pleasing communities, local adminis-trations in attractive areas tend to promote attractive area planning, in accordance with their natural environment and their history. Recently, there have been many cases where the exterior colors of newly constructed buildings are unsuitable and considered to be an eye sore. These buildings are problematic in terms of harmonizing with the surroundings and maintaining satisfying landscapes. However, it is very difficult to predict the reaction and visual perception of colors used for actual buildings.

In color planning, it is important to consider how colors would be evaluated and how they affect people physiologically and psychologically. Before World War II the colors of Japanese buildings were almost all achromatic colors, however, in the post war era, color planning began to grow in importance and buildings began to use bolder colors. By looking at universities and other academic buildings, we can see how the color trends have charged. Since universities are important public buildings in the society, we have decided to focus on studying the color trends of university buildings.

Here, we report the results of our survey concerning exterior colors used by universities in the Kansai area in Japan. The survey includes an evaluation of 38 buildings from various universities across the Kansai area. These buildings are made up of 18 university buildings established more than 80 years ago, and 20 established from 60 years ago or earlier. They were selected for the survey by their proximity being within 50km from Osaka, the center of the local government in the Kansai area.

The survey showed that the exterior walls of old buildings had been finished with brick, stone and other high quality and expensive materials. New buildings (in both Old and New Universities) have been finished with reinforced concrete, tiles, brick foundations, spray and other cheap and poor quality materials. There is very little difference between the buildings surveyed and this result. The various wall colors of recent buildings are also painted with warm colors, and old buildings are finished with achromatic colors on stone.

This result obtained from this survey, concludes that the colors of certain buil-dings are not always suitable to our living environments, but though these surveys, the color of actual buildings could be predicted and changed accordingly. In addition, it would be meaningful to consider the colors of academic buildings which are consider-ably influential to other buildings in public.

# Estimation of color concentrations for human skin color reproduction

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## Abstract

This paper describes a new method for estimating the concentrations of color substances in the human skin, using the surface-spectral reflectance. In order to analyze multiple reflections from human skin, we derive an estimation equation to represent the surface-spectral reflectance. First, we assume an optical human skin model consisting of 4 layers; the stratum corneum, epidermis, dermis and subcutaneous tissue. For deriving the estimation equation, we apply the Kubelka-Munk (K-M) theory to the optical model of human skin. Since the K-M theory was assumed an ideal optical model, we consider the transmittance and reflectance of the stratum corneum. The stratum corneum (the outermost layer of human skin) has the function of maintaining moisture and forming the surface texture. The intensity of incident light decreases based on the condition of the stratum corneum, which means that skin color depends on the surface condition. Thus, it is necessary to consider the effect of the stratum corneum. Then the reflectance and transmittance of each skin layers are predicted using scattering and absorption coefficients. The equations used for determining the absorption coefficients of the epidermis and the dermis are defined based on the Lambert-Beer law. This law allows us to calculate the concentration of each color substance in the skin. We use Anderson's data for the scattering coefficients of the dermis and epidermis. Using the above mentioned equations, we estimate the unknown parameters in human skin. The unknown parameters are the 5 concentrations of color substances (melanin, oxygenated hemoglobin, deoxygenated hemoglobin, carotene, and bilirubin), the reflectance and transmittance of the stratum corneum, and the thickness of the epidermis and dermis. Surface spectral reflectance is estimated by determining the parameters so that the equations are fitted to the measured surface spectral reflectance, using the least squared method.

In the experiment, we tested our method by comparing the oxygenated hemoglobin concentrations estimated by our method with the direct measurements. The mass concentration of hemoglobin (g/dl) obtained by a blood test was used as the direct measurement value. The oxygenated hemoglobin concentrations estimated by our method correlated strongly with the direct concentration measurements. In addition, the melanin concentration of the pigment area was compared with the healthy skin area. We confirmed the significant difference between pigment area and healthy skin area. These results show that our method can estimate the concentrations of color substances in the human skin.

# Effects of light on food appearance in color, glossiness, and visual texture

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## Abstract

This study aims to determine the effect of light on the food appearance concerning its color, glossiness, and visual texture. In this study, we conducted a sensory experiment on food appearance of dishes under different light sources. We used the digital images of the dishes to give the subject the same visual stimuli and no olfactory cues. In this experiment, we prepared 12 kinds of food dishes, Sashimi (raw fish), Tempura (Japanese fritter), Teriyaki fish, Japanese omelette, Hamburger steak, Beef steak, Green pepper steak, Shrimp in chilli sauce, Salad, Roll bread, Fried rice, and Mont-Blanc cake.

First, we measured the chromaticity values of the 12 dishes using a 2-D Color Analyzer (KONICA MINOLTA/CA-2000) under 6 kinds of light sources, 5000K and 3000K fluorescent lamp, 5000K and 3000K LED lamp, halogen lamp, and $D_{65}$ lamp, and the illuminance on the dish was 200 lx. Next, we transformed the measured data into their respective RGB values using calibration data of a display (EIZO/CG245W). This color management process ensures that the digital images are displayed with the same chromaticity values as the real object. Twenty subjects observed each image of the dishes presented on the monitor, and evaluated the "visual taste", and answered subjectively the "color appearance", "glossiness" and "visual texture" according to a 6 step categorical scale. They were female university students, in their twenties.

As a result, there were strong correlations between "visual taste" and "color appearance" in all foods. "Visual taste" and "color appearance" of Sashimi were good in 5000K fluorescent lamp, $D_{65}$, and 5000K LED; "glossiness" of Sashimi was better in LED light conditions. The results of Fried Rice showed that "visual taste" was not good in halogen lamp and that "color appearance" was good in $D_{65}$ light. Also, "glossiness" was better under the conditions of halogen lamp and LED; "visual texture" was better in 5000K LED, but not better in 3000K fluorescent lamp. The results of Beef steak showed that "visual taste" was not good in 3000K fluorescent lamp and that "color appearance" was good in $D_{65}$. Also, "glossiness" was better under the conditions of halogen lamp and LED, but "visual texture" was not different among lighting conditions. It is comprehensively concluded that $D_{65}$, 5000K fluorescent lamp and 5000K LED are better suited for lighting of foods and LED lights tend to enhance "glossiness" of foods.

These results suggest that "color appearance" is the most important factor in the estimation of "visual taste". "Glossiness" depends on the light source whereas "visual texture" was little affected by the light sources.

# Computer color matching system for metallic and pearlescent color applied gonio-photometric spectral imaging

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## Abstract

Metallic and pearlescent colours such as recent automotive exterior coatings are included many types of effect pigments, for example, aluminium and pearlescent pigment. Effect coatings show colour, sparkle, and graininess and related visual perceptions changing with illumination and observation angle. On the other hand, the manual colour matching work is very difficult and requires high human skill. Also computer colour matching systems (CCM) for effect coating require complex calculation. The main idea to reach colour and texture match by CCM is the use of combined spectral and imaging information.

In this study, a gonio-photometric spectral imaging system was developed to apply CCM for effect coatings. It was composed of 3 directed white LED illuminates, a liquid crystalline tuneable filter (LCTF), and CCD imaging device with pertier cooling unit. This spectral imaging system can get high accurate gonio-photometric colour values. Illuminates are $20°$, $45°$ and $70°$ from normal direction of sample and the CCD device captures the images via the LCTF. Each image captured in a spectral manner was divided into 8 parts accounting for slight differences in illumination. Inside these parts of the images the CIELAB colour coordinates and the spectral radiance factors are calculated and clustered.

To check the accuracy of this CCM, four kinds of materials, that is absorption pigment, aluminium flake, interference mica and a flop control agent were used to create test panels with coatings on a white and a black substrate by spray application. In the case of absorption pigment, 2 different concentration panels of each pigment ware made, and other kind of material case, 5 formulation panels were prepared to apply for calibrating the CCM. Further 8 target panels composed of 4 to 6 materials with a well-defined formulation were prepared in the same way coating. Developed CCM Software has two functions, one is components material identification, the other one is formulation calculation, and checked both functions accuracy.

Regarding components identification, almost calculated formulations were selected same materials of each target panels. And formulation accuracy ware checked colour difference value of CIELAB and DIN6175-2 between right and calculated formulation by CCM, and 8 results were confirmed small colour difference value at $20°$, $45°$ and $70°$ illuminate angle. By applying the CCM and checking the accuracy of the calculated data in comparison with the known components and formulation, the benefit of multispectral gonio-imaging and calculating method were shown in this study. Gonio-photometric spectral imaging technology was quite useful for metallic and pearlescent CCM.

# Age effect on colour emotion: An examination by looking into individual responses

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## Abstract

There is an increasing demand for consideration of the impact of age-related changes in the visual system on older people's accessibility and social requirements. For colour designers, the more important question is perhaps whether such an age effect also influences the emotional reactions to colour, or the so-called 'colour emotion.' Empirical studies in this area have typically focused on comparisons between mean responses of each age group. However there is a concern as to whether it is justified to do such direct comparisons without any inspection of responses given by individual observers. Note that colour emotion can be influenced by many other factors such as gender, cultural background, educational training or personality. Without information of individual responses, it is hard to know whether any difference shown in the mean responses is in fact attributed to the age effect only, or to any other factor.

To address the issue, a psychophysical experiment was carried out. Four word pairs, warm/cool, heavy/light, active/passive and like/dislike, were used to assess colour emotion and preference of 30 colour patches presented using a calibrated cathode ray tube display. Forty Taiwanese observers participated, including 20 young (aged between 20 and 30 years) and 20 older (over 60 years). The experimental results show that older observers tended to have stronger reactions to active or heavy colours than by young observers. Older observers were more likely than young observers to regard active colours as 'heavy,' and to regard heavy colours as 'active.' In addition, heavy or active colours were liked more by older than by young observers.

# The effect of coloured LED lighting in the emotional and cognitive responses to affective picture stimuli

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## Abstract

Two experiments were carried out to confirm how the colours of LED lighting influence on human emotion and cognition by presenting various IAPS (international affective picture system) photos containing affective content as the experimental stimuli under several coloured LED lighting conditions and by using affective rating and recognition memory tasks.

In Experiment 1, twenty five IAPS photos were presented on LCD monitor under red, green, blue, and white colored LED lighting conditions respectively, and 31 university students participated in the two experimental tasks. In the first task, participants rated the photos in valence and arousal dimensions using 7 point scale when the stimulus was disappeared after 2 seconds of duration. In the second task, participants had to press a specified button when they thought the stimulus was the photo presented in the previous task. The result of the affective rating showed that green and white coloured LED lightings induced a significantly higher response of pleasant emotion compared to red and blue ones in the valence dimension. Therefore, green and white seem to influence participants to have more pleasant and positive emotions. In the arousal dimension, red colored LED lighting evoked higher emotional response compared to other colours, so that it is likely to have a characteristic of arousal or excitement emotion. However, the result of recognition memory task just revealed a tendency that the memory performance to the photos presented under the green colored LED lighting in the first task was a bit faster than those presented in the other LED lighting conditions, but there was no significant difference.

In Experiment 2, secondary colours, cyan, magenta, yellow, and white, were used as the experimental lighting conditions. The experimental tasks were the same as in Experiment 1 and 31 university students participated from different group. The results showed less significant but similar patterns of emotional and cognitive responses overall. In the affective rating, there was no difference among the colored LED lightings in valence dimension but a significant difference between cyan and magenta was found in arousal dimension. The result of recognition memory revealed a similar pattern of response to Experiment 1, but again there was no significant difference.

The results of this study confirmed the effects of the coloured LED lightings on emotional and cognitive responses, and will provide an empirical basis for the development of LED emotional lighting system. More studies are required to identify the effect of colored LED lighting by using diverse experimental tasks and conditions.

# Bon appetit! The best versus worst light color for dining

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## Abstract

Due to the versatile advantages of energy efficiency, form freedom, and color variation, LEDs are used nearly everywhere. However, despite the technical development related to LEDs, the emotional effect of these lights has not been studied properly. In this study, in an effort to facilitate greater use of LED lighting, the possibility that certain light colors can increase or decrease one's appetite is explored. Thus, to investigate the match between the color of light and the color of food, an empirical study consisting two sessions was conducted.

In the first session, the subjects were provided with seven dishes of red, yellow, green, blue, violet, black, or white non-staple food. They were asked to find the best light color for each dish using the LED lamp. Once the best color was selected, the Chromaticity (x, y) and illumination (lx) values were measured. The impact of the selected light was compared with a daylight condition by switching off the LED lamp. In this way, the subjects went through the same procedure to find the worst light color as well.

The second session was intended to provide a more natural setting. Hence, as food stimuli, a salad, a piece of blueberry cake, kim-bab (Korean Sushi), and various sweets were prepared. As in session I, the subjects were asked to find the best and the worst light color and to compare the chosen light color with a daylight condition.

Based on the data measured in terms of its chromaticity and illumination, the selected colors were sorted into their color naming groups by referring to the CIE chromaticity diagram. The best and worst combinations were identified and it was found that light can have an impact on appetite even when there are differences among individuals. Orange followed by yellow were the most appropriate light colors among various food colors, whereas red followed by daylight may reduce one's appetite, particularly when the food is green or blue. The result of this study proposes a creative means of lighting for a dining environment that can increase or decrease the diner's appetite depending on the food color.

# Research on the elderly people's color distinction scope subsequent to color

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## Abstract

Aging of population is emerging due to the extension of an average lifespan along with the development of health and medical technology and with the rising interest in health. With the increase in age, the function of a sensory organ is aging. Among the changes in vision which takes up more than 80% of information acquisition, the yellowed eye sight phenomenon is the main reason for the decline in color-perceptive ability & changeable color distinction ability according to colors. Due to the visual characteristic subsequent to aging, the elderly might suffer discomfort because environmental colors they see in daily living are diversely changed or might suffer discomfort because important information is not perceived. 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.

In the preceding research works related to the elderly people's color perception, they examine the change characteristic of color perception and suggest the confusing section of several colors and tones, but there still remains to be desired in dealing with concrete distinction scope subsequent to the value and chroma in the same colors. Thus, this research is going to suggest the basic data for color arrangement taking safety into account in time of color planning within the same colors by analyzing the color distinction scope quantitatively subsequent to value and chroma by individual color from a viewpoint of the elderly people.

This research did experiments targeting the people in their 60s and 80s under the north side daylight from 10 am to 3 pm. The illumination of experiment side was between 1000 and 2000 lx(average 1542.62 lx) and color temperature was the average of 6760K. This research was done by direct experiment by suggesting the Munsell chart consisting of 5 major colors(5R, 5Y, 5G, 5B, and 5P) to elderly. Then the common distinction scope was extracted through frequency analysis.

# The relationship between the brand images of cosmetic brands and the colors applied in their merchandising spaces

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## Abstract

The aim of this study was to analyze the relationship between the brand images of cosmetic brands and the colors used in their merchandising spaces. First of all, eighteen cosmetic brands were selected. Secondly, objective data about the brands were collected. Each of brand images was determined by analyzing these data, and was described using three adjectives derived from the Kobayashi image scale. After this, the merchandising spaces were photographed. White balance of all photographs was adjusted accordingly to offset the effects of halogen lighting. Colors were then studied in order to characterize the overall color usage in different merchandising spaces. Finally, the colors used in each brand were analyzed in two ways. First, the relationship between dominant colors and brand image adjectives was defined. Second, the relationship between the brand colors and Kobayashi image areas was examined.

|  | Hues | Color Combinations |
|---|---|---|
| **Overall Use of Colors in Merchandising Spaces of Cosmetic Brands** | 1. They can be classified into achromatic, chromatic, and metallic colors. <br> 2. Most achromatic colors had low value. <br> 3. For chromatic colors, brown, red, blue, purple, and green hues were used, and most colors had intermediate to high value and high saturation. | 1. Every combination consisted of a dominant color and multiple supplementary colors. <br> 2. The total number of colors used in most combinations was less than four. <br> 3. In most cases, achromatic and chromatic colors were used together. <br> 4. There was a frequent use of accent colors and contrast in value. |
|  | **Dominant Color and Brand Image** | **Brand Colors and Kobayashi Image Area** |
| **Relationship between Brand Color and Brand Image** | Same adjectives appeared repeatedly according to the dominant colors. Most frequent adjectives were, for White: Modern and Feminine, Black: Elegant, Brown: Simple, Pink: Merry, Cheerful, Cute, Purple: Feminine, Delicate, Polished, Red: Healthy, Mild, Natural | The brands with similar colors, color combinations, and especially the same dominant colors were concentrated in the same or neighboring area. |

As shown in the table above, the brand images and colors used in merchandising spaces were closely related to each other. Each cosmetic brand has a meticulous color usage plan for their merchandising spaces in order to effectively communicate their brand identity to the customers. This can also be applied to any elements that are influential in controlling the brand image, suggesting that establishing the brand image through the usage of proper colors is an extremely effective and powerful method.

# A research on the development method of a practical digital color palette using natural flower images

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## Abstract

In the modern society, where designing is done mostly with computers or other digital devices, being faithful to the original colors and portraying designs naturally has become increasingly important. Therefore, this research aims to understand the characteristics of digital devices and colors and by doing so, to enhance the satisfaction of the designers work by providing them with data about the nature of the original colors. Therefore, in order to reduce the differences of color space of digital devices, a characterization of digital cameras and color image cluster program were conducted. As the naturalistic lifestyles began to be a growing trend in the design market since 2000, the usage of floral patterns and colors has increased for example fashion, fiber, product surfaces, wallpapers and interior fabric designs. With this fact in mind, we started the research to develop a flower color image palette. Studies show pigments that determine the color of a flower mostly are mostly located in the petals. Upon analyzing the colors using the pigments in the flower's petal, different characteristics in chromatic and lightness were noted. White flowers had high lightness and low chromatic; yellow flowers had a proportionate relationship among the two factors while orange flowers displayed similarity in lightness with diverse chromatic. Red, magenta flowers had higher chromatic than lightness and pink flowers showed lower chromatic in comparison with lightness. Violet, mauve colored flowers had a balance in chromatic and lightness and blue flowers had low chromatic and a relatively high lightness. Purple, black flowers showed low in both lightness and chromatics. On the basis of this data, an ACO file with classified flower colors was made to be utilized as a flower color swatch on Photoshop and illustration programs. By a systematic approach on digital colors, we developed a practical supporting tool to utilize a more effective and natural flower colors in the designing environment.
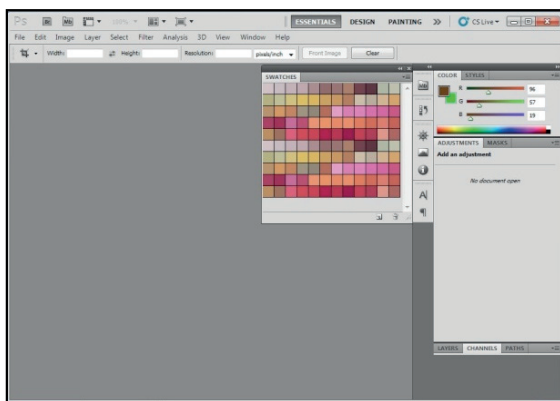
Figure 1 : Color Palette of Rose Colors
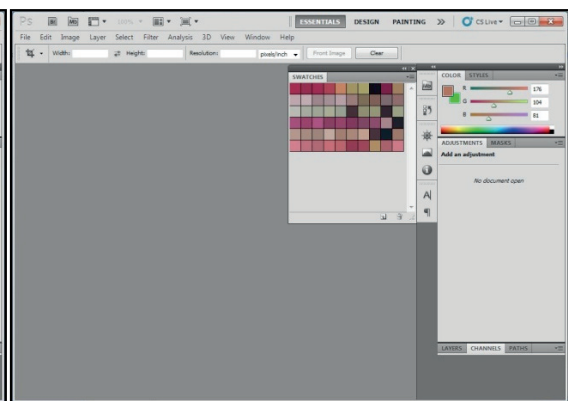


Figure 2 : Color Palette of Transvaal daisy

# Colour change in printing inks caused by light exposure

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## Abstract

Every material changes its colours if it is exposed to light for much time: this event is called photo-damage. The effect depends on the energy and the spectral power distribution of the incident radiation: these proprieties are characteristic of the emitted light source. Contemporaneously, the colour changes depend also on the proprieties ability of the receiving material of absorbing the light and of being modified by it. This propriety called relative spectral responsivity $s(\lambda)_{dm,rel}$. Every material has its own responsivity to the photo-damage specific to each wavelength of the incident radiation.

In the Photometric Laboratory of the Padova University some coloured ink samples have been submitted to an accelerating aging test, in order to investigate their fading process. The aim of the experiment is the comparison between the results obtained with the coloured inks under test and the conclusions derived from analogous experiences carried on with different materials. In this way, a common descriptive model for several materials could be deduced. Moreover, the knowledge of the relative spectral responsivity $s(\lambda)_{dm,rel}$ of a material is helpful to define the emitted spectral of the light source which should light an art work in order to preserve its colours.

The photo-damage process has been reproduced by a continuous radiant exposure of the coloured printing ink samples put inside an accelerated aging chamber; a wide-spectrum light source was used. During the test, the spectral reflection coefficients of the samples have been constantly monitored and recorded by a spectroradiometer. Several lighting conditions in terms of intensity and spectral components of the incident radiation have been reproduced with the aim of investigating as many aspects as possible of colour fading. The colour differences $\Delta E$ of the samples between two successive measurements have been analysed versus the radiant exposure *H.* that is the total incident energy on the samples. Later, from these $\Delta E - H$ laws, the relative spectral responsivity $s(\lambda)_{dm,rel}$ and the threshold radiant exposure $H_s$ of each coloured inks have been calculated. The first one indicates which wavelengths are more dangerous for the fading of the ink and so should be avoided. The second one corresponds to the maximum of incident radiant energy on the sample before it fades.

During the fading process, the spectral reflection coefficients of each sample flatten their diagrams and increase their average values up to the unit value. From the $\Delta E - H$ laws it is possible to note that the fading process starts very fast and then it continues more slowly until a regime value is reached. The relative spectral responsivity $s(\lambda)_{dm,rel}$ of each sample has been calculated; the results do not completely agree with the conclusions of analogous experiments carried on another materials described in literature and could required some new considerations for their interpretation.

# Colour filtering of lighting systems based on wLEDs to improve their colorimetric characteristics

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## Abstract

New "white" lighting systems based on light emitting diodes (LEDs) have appeared in the market with many advantages over other light sources. However, some reports indicate that the wLEDs are not optimal to get an adequate visual comfort.

On the other hand, a light source has a good colorimetric quality whether it provides a wide colour gamut, it has good colour discrimination and keeps the naturalness of the scene. For many years there have been many works related to the colorimetric assessment of light sources based on the study of the colour rendering. In fact, the CIE adopted in 1974 an algorithm for calculating a colour rendering index for light sources. In this way, it is also known that some visual experiments contradict some of the results obtained with the current colour rendering index proposed by the CIE. Furthermore, another important aspect to consider is to know the chromatic diversity offered by the illuminant, that is, the number of colours that can be obtained using this illuminant. These two aspects provide information on the effects produced by a light source and it can be very useful to design new light sources.

Considering all of these aspects, our objective was to design new lighting systems based on wLEDs with an optimized colour rendering index filtering their light emission in order to go beyond the colorimetric and visual quality of the incandescent and luminescent light sources.

In this work, in order to filter the LED light emission four coloured filters were used. The filters were chosen trying to emulate the HP2 lamp because this lamp is normally used in purchase and sale installations. Their spectral transmittance was measured with the UV-VIS UV2-200 ATI UNICAM spectrophotometer. The light emission of the wLED was modified taking into account the set of coloured filters. Secondly, the CIE colour rendering indexes, the colour temperature and the volume of the theoretical colour solid associated with the filtered LED were calculated in order to compare the new colorimetric characteristics with those of the wLEDs. The theoretical colour solid was obtained following the method proposed by Li *et al* and the volume was estimated with a convex hull program due to its low computational power. We found a filter which improved the colorimetric characteristics of the wLED. Therefore, it is checked that it is posible to improve the colorimetric characteristics of light sources modulating their light emission.

# Semantics of shape-color combinations

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## Abstract

**Objectives and scope.** Every single colour has its basic character and meaning, but carries at the same time itself its semantic polarity with its positive and negative aspect in relationship to other colours and the surrounding environment. The same applies to shapes, which are as colours semantic information carriers. However, the contrast of positive and negative aspect of shapes relies on their dynamic properties, where the contrast is only a polar opposite form. Basic characteristics of colours and shapes are derived from the perception of the characteristics of the individual colour sequences in natural cycles, justified in the Periodic model of colours and shapes. Informative potential and the effect of colours and shapes are obtained only by combining colours and shapes in new phenomenon, which means that the final result still depends on relationships among constituent colours and shapes. The relationships are quantitative presence of colours and/or shapes, qualitative identification of colour or shape by their typology and tectonic by defining the position of each element - colour or shape. Since colours and shapes may occur in extremely complex conditions and states, I will limit my presentation to the definition of basic classes of the complex colour-shape structures, from which other more sophisticated relations among colours and shapes are derived.

**Methods and results.** Basic classes of the complex colour-shape system are classified by means of the Periodic model of colours and shapes. With the help of Gestalt theory I tried to define the evaluation system of relations among colours and shapes in a particular environment. The dramaturgical role of colours and shapes is classified by their position in the compositional quadrant, but the dynamic properties of shapes are defined by their tectonic properties of the positional alignment.
Basic colours have certain semantic features and tendencies, which are based on relational values and ordered by model from Gestalt theory.

**Conclusions.** The relations between colours and shapes are quite complex, but colour schemes can also be used for the interpretation of shape schemes, as shapes have a classified similar properties patterns as colours. There will be presented basic polar Shape-Colour combinations, which could serve as foundation of the grammatical system of visual communications.

# Bright fabrics: From silk to LED

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## Abstract

1. *To weave gloss*. Textiles, in order to be more attractive and valuable, have always tried to capture the light. To do this, they used rare fibers and special works. The shiniest of the fiber is most certainly the silk, which apparently was known in China as early as 3500 B.C. and that was on sale in Europe in the form of fabric.

   During the Roman Empire, this rare and expensive commodity charmed kings, emperors, aristocrats and wealthy landowners, so as to raise the issue of numerous sumptuary laws to limit their use. It is said that two monks, who managed to hide the silk bugs inside the cavity of their walking sticks, evaded the Chinese monopoly. During the time of the Byzantine Emperor Justinian, in the West began a silk production destined to the courts.

   Silk weaved on satin and velvet hides the warp and shifts the light on the surface, giving it a soft and diffused shine. In this process were employed refined techniques of goldsmith in order to make gold spinnable.

2. *To apply splendour*. Extremely tiny rolled silver sheets were firstly gilded with pure gold on the outer surface and then were cut into strips, from 200 to 400 thousandths of a millimetre of width. Afterwards, they were wrapped in a spiral on silk fiber and then used to create shining embroidery adorned with gem-set. These shiny fabrics became the prerogative of kings and emperors who, wrapped in their glory, made visible their divine origin to the people. Other interesting techniques were applied to textiles in order to capture flashes of light, such as the creation of metal sequins of different sizes and dimensions, gilded and rounded, of which there are numerous examples during the Italian Renaissance.

3. *To emit luminescence*. Since then, the aesthetic and technical research implemented to capture the light has been developed simultaneously in art and textile productions. Up to the Eighties, sparkling textiles were expression of luxury and were used in gala clothing. Following the spread of techno music and street style, these textiles have acquired more meanings. In the same years, fashion gets possession of the luminescent textiles invented to be used in safety clothing. Reflector pull-outs and fluorescent textiles were used by a young generation beginning to dance in dark spaces illuminated by strobe lights and to use the visual properties of these textiles to increase the explosion of colours.

4. *To transmit light*. Today, the ability to make fiber optics flexible and suitable for weaving, together with Led application over fabrics, has enabled the production of textiles that emit light.

This paper aims to illustrate the route that the textile industry has undertaken, from the ancient to the present time, in order to intercept and transmit the light.

# Colour design of commercial building at Amphawa canal community using NCS colour notation

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## Abstract

To repaint the commercial building at Amphawa canal community, first the original paints used on the building were investigated. We found that they were originally painted in chrome yellow and some were repainted in many other colours in later years. New schematic must create a suitable identity to the old place and from our historical background studies. Therefore, chosen colours were dominated by green hues with many nuances such as S2020-G50Y, S3010-G30Y, S1010-G30Y, S2020-G30Y whereas yellow and pink of a few subsequent nuances such as S1010-Y30R, S0520-Y30R, S1010-Y80R were selected.

To ensure that the painted colour on the building is perceived the same as the selected colour (inherent colour), the experiment was carried out by selecting some buildings as our prime experiment subjects. First, parts of exterior of the building were painted by selected colours. Then forty observers who had normal colour vision were asked to match the NCS colour patch (2.5 x 5 cm) to the painted wall under direct sunlight (5500K) and under shade (7000K).

The painted colours were analyzed by plotting the inherent colour and perceived colour in NCS colour space. It was found that the majority of observers perceived some slightly colours shifts in every aspect of NCS colour notaion such as hue, blackness and chromaticness. Under direct sunlight, colours were perceived towards more blackness and more chormaticness. Hue shift was dependent on colour hue. The green colour was perceived to have more green hue while yellow-red hue was perceived to have more red hue. Under shade, colour shifted toward more blackness for green colour and less blackness for yellow-red colour. Chromaticness is not changed in these circumstances.

The results from this experiment were part of our decision to paint all commercial buildings. Since this market is on the canal bank of the evening floating market and its peak activities happen after sunset. The colours of the commercial building are perceived somewhat less colourful because of the low light intensity and human vision shifts from photopic to scotopic. Experiment results shown that our inherent colours change only slightly in shade. Therefore we decided to paint the colour as we selected from NCS notation.

# Mobile sun-shading devices: Changing the colour of buildings' façades and places

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## Abstract

This paper summarizes the results of a research made by the author inside the 'Colour and Light in Architecture' Research Unit at Iuav University of Venice, Faculty of Architecture and inside the PhD course of Building Technology at Ferrara University.

In contemporary buildings, where large translucent façades must enable compliance with specific standards of comfort, the external mobile sun-screens have assumed a gradually more and more strategic role. In the past, before the introduction of lightweight construction systems, the windows were generally smaller than today and also the sun-screens were smaller. Today the sun-screened surfaces can be very large according to the size of the glass panels on the façades. Entire walls are covered with adjustable brise-soleil, shutters or awnings. They can be made of a wide range of materials: textile, metal, glass, plastics, ceramics etc. They are colorful and, acting in synergy with the light, they help to change the chromatic conditions of façades, of interiors and even of the surrounding environment.

The objective of this research was to identify the most common colour combinations used in contemporary architecture, for integrating mobile sun-screens with the façades of the buildings and places. The research has produced guidelines for the expressive design of the sun-screened façades, aimed at architects, designers, manufacturers and even local governments for building regulations.

To achieve these objectives the research started with an analysis on the state of the art: historical research, survey law, classification of shielding systems on the market (shutters, awnings and adjustable brise-soleil). Then we proceeded with a catalog of over 100 case studies of contemporary architecture by analyzing parameters such as shielding system, location of the sun-screen, components, materials, screen size, colour of the screen, colour of the façade, colour combinations and colours of the context.

The processing of data, obtained from this analysis, has produced the standard configurations that have been collected and classified into groups, by relating the type of façade, the type of shielding and the most common colour combinations. Everything was collected in a system of guidelines for the architectural plan and also translated into a project of software.

# Measuring beer haze and preference

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## Abstract

A proposed technique for defining the most preferred appearance of beer (lager and bitter) in terms of colour and haze (i.e. cloudiness or translucency) has been investigated. Conventional hazemeters measure beer haze by either detecting light 90° to the light source or using forward illumination geometry. Beer colour, however, is measured at a standard-specific single wavelength, e.g. 430 nm for the European Brewing Convention (EBC) standard. The new method involved a combination of colour measurement of the beer samples using a tele-spectroradiometer, measurement of turbidity using a hazemeter and visual ranking of beer samples in terms of preference in a psychophysical experiment under a predefined viewing environment.

The outcome of this work was to enhance the appearance of two existing commercially-available beers. Data obtained from this experiment also allowed cultural differences towards beer preference to be explored and the acceptability of various beer colours and haze levels to be determined. This information can be used by the brewing industry to fine-tune their products to match the most preferred appearance in different parts of the world.

# Teaching ideas and aspects for a new spacial research on the interaction between light, space, and color

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## Abstract

As part of my teaching research, I continued to analyze in ever greater depth the possibilities that this topic can open up, topic which is clearly connected with my paper "Development of Intuition Skills about Light/Color", presented at the IUAV Conference on "Color and Light in Architecture", held in Venice last November.

These exercises, using essential structures, refer to the variability of color, light, and space, enhanced through different points of view. In these structures, the color component defines constantly changing space placements, while providing unexpected color matches with "surprise effects" as far as color perception is concerned. Color, in turn, integrates with either natural or artificial light and with space, which becomes a three-dimensional support. These studies can also be applied for teaching design, in order to develop new application opportunities, by extending perception spaces also for designed objects. You can then move further on with chromatic connotations. Natural or artificial light is then used to highlight different composition dynamics, thus promoting a real discovery of color linked to concepts of spatiality and brightness. Diversified chromatic features, depending on their position in space, will offer a valuable study for design analysis. If tonal colors are selected, there will be a more harmonious relation with natural light. Conversely, if timbric colors are chosen, there will be stronger contrasts. Under artificial light, there will be yet another outcome, which can be analyzed with proper light and shadow constructions.

Color in my "3D expression" informs the direction of planes, the perception of surface extension, the depth and projection of volumes.

The obtained results will offer ever changing perception solutions, thus also increasing design opportunities.

This method, when widely applied, extends from the object we have designed to our human landscape, our experience of shapes and the environment, by creating spaces for a new creativity, towards an aesthetic approach in which perception interferences offer a more complex and conscious vision.

The various constructions for teaching referred to here have been designed and produced with the collaboration of students of the Art High School Klee-Barabino, in Genoa, Italy.

The works by Verner Panton will also be mentioned as the author who has based the expression of his environments on the interaction between color and light.

# "The Sculptural Lighting": Applications in monumental contexts of an artistic technique based on colour-light-texture interaction

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## Abstract

As a sculptor, my interest has been attracted by the consequences on appearance of illumination filtered by textured, coloured, and translucent materials of variable thickness and chromatic strength. Therefore I have been examining the versatility of the visual responses arising from the combination of light, colour, and transparency on surfaces patterned by inlaying and carving.

The possible uses of the multipurpose sculptures we created are:

a) in matter of lighting, with self standing independent sources, or, in conjunction with existing traditional installations, by artistically filtering and modulating the output of old and new sources, e.g. LEDs;

b) decorations;

c) as displays (information, symbols).

The areas of interest and operation may be:

1. historical centres (buildings, cathedrals, indoors as well as outdoors);

2. design and furnishing private apartments and residences in modern buildings of various kinds;

3. restaurants, clubs, etc.;

4. festivities, celebrations, events, private initiatives.

In monumental contexts we worked respecting the constraints and restrictions of the Monuments and Fine Arts Departments as well as considering the appearance of the environment on the basis of its original characteristics, architectural style, building materials, and prevailing colours during the alternating phases of daylight:

a) in various Florentine churches (e.g. the Santa Maria del Fiore Cathedral) the traditional wax pillar candles had being replaced by oil lamps fitted in cylindrical plastic moplen tubes. In order to improve the previous solutions and the global environment we created translucent textured colored cylindrical paraffin filters to be installed in place of the plastic tubes.

b) we created temporary artistic installations in various monumental contexts (e.g. Palazzo Vecchio) by using translucent colored textured sculpture-lamps (indoors electrically supplied, outdoors with burning oil sources) enriched by carved and inlaid fleur-de-lis, the symbol of Florence.

Technical data:

a) materials: high melting point paraffin and polymers;

b) tools: carving and inlaying tools.

light intensity: chosen in relation to the factor of diffuse transmission (re: transparency), depending both on the density of the material and on the thickness of the envelope of the source;

# Image based technique for colorimetric characterization of the light field emitted by LED projector with variable CCT for museum lighting

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## Abstract

When we make reference to the word "cultural heritage" we mean to show the complete assets of works produced by the arts of painting, sculpture, design and architecture. In this field of application, the fundamental goal of lighting is, therefore, to enhance the work of art, by stimulating the proper perception through attractive elements that hold the viewer's attention.

The lighting of paintings in the museum should be chosen in a way that optimizes the aesthetic experience of the observer. Usually lighting sources with a colour temperature of about 3.000K is employed to reach and maintain an average illuminance level on the surface of work ranging from 50 to 200 lux.

There are few studies and experiments that take into account the limitations imposed by the human visual system when viewing a work of art, and in the absence of exhaustive studies and research on this subject, several experts in lighting design, claim that the colour temperature of light closer to the dominant hue of colours that most characterizes the artistic work, is able to enhance the chromatic meaning.

In museum environments where there is an alternation of sets it is needed to have a lighting product, using LED sources which is capable of producing beams of white light with variable color temperature in the range between 2.700K and 10.000K and a spectrum rich in all frequencies of the visible range.

This result is reached by a 5-channel LED lighting system, that are mixed in right proportions and it makes possible to obtain the desired range of color temperatures and color rendering index value suitable to the museum's application.

The aim of this paper is to deal with the research techniques adopted for establishing the proper mixing of LED's power supply in each of the 5 channels of the device and to evaluate the colour distribution (especially in terms of uniformity) of the light field projected at given distance, in accordance with the variation of colour temperature and beam aperture of the optics associated with each LED.

The chromatic evaluations were carried out using a series of prototypes: the beam emitted from the projector was directed onto a screen and several shoots have been taken by a monochrome CCD camera with the interposition of three colour filters (which simulates the response of the spectral sensitivity of the 2 degree observer) between the optical system and the sensor plane. Several maps of the XYZ values were acquired by the camera and a series of maps of correlated colour temperature were evaluated in accordance with the different lens aperture and adjustment in light colour.

# Impression differences in colour vision characteristics

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## Abstract

Colour designs which consider the diversity of colour vision characteristics are recommended in today's society. The opportunities to design with assistance tools, such as "colour vision simulators" are becoming more accessible. They were originally made to check the colour discrimination characteristics of colour vision deficiencies. However, the users of these systems, trichromat designers in many cases, often feel insecure of the changes of the impression in their colour design caused by the simulators.

The aim of this study is firstly to establish a guideline to follow when trichromat designers use a colour vision simulator. Secondly, to investigate the impression of colour of people who have colour vision deficiencies.

We examined the changes in trichromats' impression of colour when using a colour vision simulator, and evaluated whether those changes were predictable. We asked 30 trichromats to evaluate with a scale of 1 to 4 whether each three-colour combination pattern with three different colours represents a particular adjective. We used 30 sets of patterns and adjective. The experiment was carried out under two different conditions for the trichromats: "original (without using the colour vision simulator)" and "with the deuteranope simulation mode on a colour vision simulator." Then, we carried out the same experiment without the colour vision stimulator for two dichromats (deuteranopia), and we compared the results with those of the trichromats.

In many of the three-colour combinations patterns, the evaluation by the dichromats was close to the evaluation of the trichromats under the original condition. For the results where evaluation points of the trichromats varied between the two conditions, we found that the change can be explained by the combination of the hues in the three-colour combination patterns. Their impression changed significantly when the three hues were distributed along the b* axis, on both the first and the forth quadrant or both the second and the third quadrant in the a*b* plane. This result suggests that dichromats have possibilities to correct their lack of "warm-cool" information along the red-green axis. In addition, many of the patterns whose evaluation points varied only among the dichromats had low average luminance.

Thus, we found that the colour combination patterns that had different impressions among the three conditions are predictable by the colour attributes they have, and we can suggest what should be taken into consideration when trichromats work designing with a colour vision simulator.

# Classification of fragrances by their similar psychological images with colors (1) - psychological and physiological study of harmonious color-fragrance combinations

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## Abstract

Cross-modal perception or multisensory perception (or multisensory integration) is a subject of current interest to psychological and neuroscientific researchers. In order to attempt a classification of fragrances based on their harmonious colors, the present study aimed 1) to extract matching / non matching pairs from various color-fragrance combinations, 2) to obtain their psychological and physiological effects, and 3) to derive the common and principal factors which present similar psychological impressions and feelings (mood) of colors and fragrances which might be useful for classifying fragrances.

One hundred female student subjects were randomly assigned one of 15 fragrance stimulations and were asked to select two sets of three colors from a color chart consisting of 18 colors (15 chromatic colors and 3 achromatic colors), one that matched the fragrance and another that mismatched the fragrance, to extract matching-pairs and mismatching-pairs. After the matched / mismatched pairs of color and fragrance were obtained, the subjects were also required to rate the psychological images of those pairs by 16 pairs of adjectives for the SD method (semantic differential method) along with 20 adjectives for mood assessment under exposure to the given color-fragrance combination inside a booth for examining changes of impressions and mood.

Factor analysis was applied to the data of both SD evaluation and mood assessment of combined data of color and fragrance. Five factors were extracted and it was found that the common factors which determined the impressions of color and fragrance were *clear* and *mild*. The results indicating that *clear* corresponds to the lightness of colors with fresh fragrances while *mild* corresponds to the hue with feminine and sweet fragrances suggested that fragrances might be classified with their harmonious colors by the axes of *mild* and *clear*. In addition, the well matched color-fragrance combinations reflected responses moving in a common direction in terms of the impression and mood. In the assessment of the physiological effects, the CNV (contingent negative variation) brain wave confirmed that matched combinations tended to sedate the emotions, while mismatched ones stimulated the emotions. Further, the indexes of the autonomic nervous system (electrocardiographic monitoring) and internal secretions of Chromogranin A (CgA) level in saliva suggested that the mismatched combinations produced mental stress. In addition, using the factor scores of the extracted factors of mood assessment as dependent variables, and those of *clear* and *mild* factors of SD evaluation as independent variables, a stepwise multiple regression analysis was conducted to estimate the relationship between the results from SD evaluation and mood assessment. The results showed that the stronger the bright and clear impressions from the *clear* factor and the warm and feminine images from the *mild* factor were, the more positively feelings were found to increase. It is also suggested that the effect of mood might be predicted according to those two factors.

# Software to examine and improve legibility of colored documents for protans and deutans

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## Abstract

This paper describes software and methods to improve legibility of colored documents for the people with color vision deficiencies, particularly protanopic and deuteranopic vision (red-green color blindness). The aim of the software is to help color deficient people distinguish and separate out the colored texts from background and to use accessible colors in the colored documents by means of color replacement methods and image processing methods. The proposed software is mostly used by the non-professional people who don't have technical know-how to create color barrier-free documents for color deficient people. Even though it is difficult for the non-professional people to consider color vision deficiency carefully and to select appropriate colors in the documents, the proposed software can help them select appropriate colors easily.

The proposed software examines the images of colored documents whether the font colors in the documents are accessible to color deficient people by the use of dichromatic simulation and legibility evaluating function. If the examined document turns out to be inaccessible, inadequate colors are replaced automatically with accessible ones according to any of three methods as follows:

[1] Color optimization method: Color optimization method chooses replacement colors from the same color categories of inaccessible colors and also maximizes color difference between colored texts and background from the point of view of protanopic and deuteranopic vision. The said method can integrate combinatorial optimization of colors into itself.

[2] Color mapping method: Color mapping method chooses replacement colors according to the color mapping table assembled by Ito et al. The color mapping table consists of twenty two colors that can be identified by color deficient people (protans and deutans). These colors have been determined through color-naming observations by several dichromats. The color mapping method can run faster and more reliable than the other method, because the said method based on the color mapping table doesn't need so much CPU power and prevent the occurrence of complexity on combinatorial optimization of color.

[3] Image processing method: Image processing method has no limitation on the number of colors and can process any full-colored image of the document. This method enhances the edge of colored fonts in the document and enables color deficient people to distinguish and separate out the colored texts from their background.

# Conceptual metaphor and the interaction between color and light: Light is color, seeing is receiving light, seeing is color

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## Abstract

The objective of this paper is to employ the conceptual metaphor model to identify the abstract mapping humans use to cognize color terms in language. The theories of conceptual metaphor and embodiment in the cognitive linguistics approach are relevant tools to operate a semantic analysis of chromatic terms and dimensions in natural language. The mapping that is generated reveals how the signification of color is accessible through the distinguishing of light. By concentrating on LIGHT and the interaction with the domain of COLOR, our conceptualization of color terms in language emerges.

The lexical frame of COLOR still lacks complete conceptual mapping. This is due to the complexity of interaction between color-light and color-substance and its polysemic nature. I propose that we project our embodied experience of color onto different domains depending on the association with the color and the specific surround. In conceptual metaphor models the mapping process is phrased in a specific manner. It is structured as: TARGET DOMAIN 'A' IS SOURCE DOMAIN 'B', projecting from the more concrete SOURCE onto the more abstract TARGET. This phrasing is used to map the concepts that are realized in the form of metaphorical linguistic expressions. All of the examples presented in this paper as entailments of color metaphor mapping are natural language usage based texts that have been accessed from the Corpus of Contemporary American English, from Google (by inserting the chain of lexemes), and from the Master Metaphor list (UC Berkeley). Our primary conceptualization is evident in the conceptual metaphor LIGHT IS COLOR. An example of the linguistic realization of this concept is: Red at night sailors delight. The color red is a result of our perception of light in sky. Hence, an individual can see a color light and give it a color name. To explain this perception and integration process we have a series of concepts that form what is known as a complex metaphor. This complex metaphor includes: PERCEPTION IS RECEPTION, SEEING IS RECEIVING LIGHT [PHOTONS, PARTICLES, WAVELENGTHS], LIGHT IS COLOR, thus SEEING IS COLOR. This paper describes this complex metaphor with examples to illustrate how humans develop a network of metaphors in language use and color perception. Identifying a color through language is a perceptive gestaltic act that tells us what 'ground' is associated with the 'figure' of color. The process of identification is codified through image schemas, conceptual metaphor and metonymy, which allow us to rapidly identify what color code the entity (either abstract or concrete) should have. This process begins with light and our conceptual interpretation of light in our embodied experience of it as a color with its three dimensions of hue, lightness/brightness, and saturation.

# The *colourlessness* of the Zener diode

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## Abstract

Xenophanes' *Apeiron*, one of the most impressive intellectual creations in the history of science, was simply colourless and yet sustained our colourful world. Science challenges the limits of the imagination just as well as art does, and they may set their way in curiously opposite directions, and yet somewhere we may find the realm of mathematics 'between' them or 'inside' both or 'connecting-disconnecting' them. The notions of c*olour* and *colourlessness* have definitely arisen at the trial of our understanding.

Mathematics arose powerfully *deus ex machina*. Abstraction has taken command, and we recognize a greater sense in Xenophanes because the *unseen* seems a greater challenge than what we see.

And yet my hand moves and galaxies move: their colours move. My fingers have the strength to hold my cup of coffee preventing it from falling. But far more important, my hand, my body, my cup, the universe – all move in a colourful *space-time* whose colour helps me to understand its hidden secrets.

Nonetheless, it seems that colour came to endure within the art-science realm and yet it was finally brought up through some *colourless* paradoxes. Xenophanes' *Apeiron* seemed to have moved into a lattice motion inside semi-conductors. The interesting behaviour of the Zener diode is clear under the mathematical shape of a colourless mathematical function that shows 'unexpected behaviour' from the conventional understanding of electrical behaviour. What colour could replace such an effective understanding? Perhaps it would be senseless to think about colour when a new miracle of mathematics came under a new shape: Boolean logic. The digital age had arrived.

Suddenly we come to a surprising zenith in the long art-science history. Mathematics at the core of semi-conductors was not abstract enough because it needed to proceed into a 0-1 logic based on full controlled matter infused into *logical doors* and other similar devices that, nonetheless, have shown to be the only tools that were able to bring to us the most impressive colours of the universe and thus we may combine them with this colourful based world we construct. The most impressive colourless devices one can imagine have brought us the most impressive colourful universe that no one could imagine to be there beyond the dark night sky.

# Perception of contrast on different backgrounds

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## Abstract

With psycho-visual experiments, the influence of varying backgrounds and room illumination on perceived colour differences is evaluated. The presented work is restricted to values on the grey axis with the aim of extending the study to colour values. High-end LCD monitors are used as a test platform (EIZO CG220, 120cd/m$^2$).
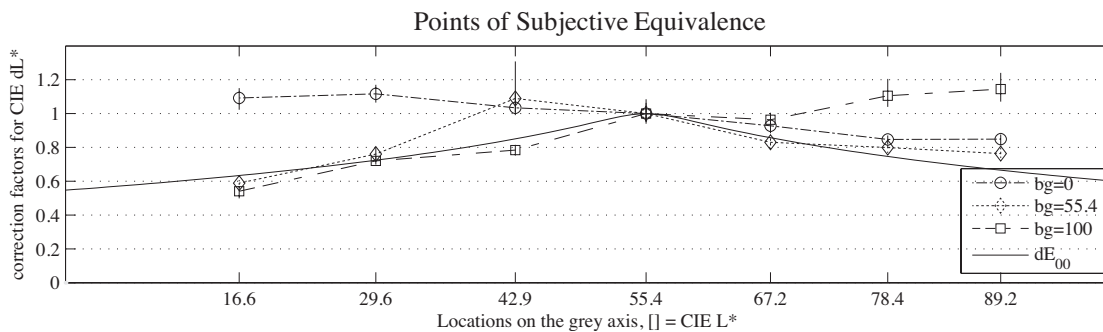
*Figure 1: How to express contrast in units relative to CIE dL\*, accounting for background effects.*

We presented two pairs of grey differences in each trial, which were compared to one another. Measurements and judgements were carried out in an illuminated room with about 350-500 lux when measured in front of the flare-baffled monitor. We measured the grey axis of RGB with a Minolta CS2000 radio-spectrometer in the illuminated room. Applying the photopic 2° normal observer curve to these spectra defined L\* values corresponding to RGB greys. Along the lightness axis, we located seven values (see abscissa in figure). For each location, three lightness differences were determined: 4, 6 and 8 dL\* approximately, and these 21 pairs were used in the test.

In a pre-test, we had based stimulus selection on measurements in a dark room and observers almost always indicated that the differences near the black point were smaller. Turning on the illumination altered the values measured near the black point by more than 7L\*, though differences were affected by less than 4dL\*.

For each background (white, grey and black), 41 judgements were made per session (2214 in total), regarding the question whether the first pair appeared to have a lightness difference smaller, equal or larger than the second pair. We transformed observer choice data to ratio scale values using a Bradley-Terry model incorporating ties. Figure 1 shows, how the measured differences on each of the three backgrounds would have to be corrected in order to account for background effects.

As a conclusion, a working environment with typically a minimum of 500 lux will alter contrast perception on displays. The same holds for a white background as used in many programs for creative professionals. Colours perceived in such an environment should be modelled as interaction of a light source and colour due to surface reflection.

# Enigmatic search: Light and colour in today's urbanscape. A pleasurable paradox

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## Abstract

This paper explores ways of introducing daylight into architectural environments in an everyday manner as well as theoretically in the context of contemporary architectural discourse. Architects and artists, often in collaborative works, e.g., the Novartis Campus – Forum 3 management headquarters building in Basel, use traditional or innovative surface textures and specific material qualities in order to deal with daylight and colour in a dynamic and interactive way. Seemingly paradoxical means – transparency and opacity, glossiness and roughness, reflection and superposition – shape daylight and make colour emerge, space appear and appearance change. Unlike artificial lighting daylight causes subtle colours and complex shadows to appear. Its cyclical course and daily and yearly rhythms produce a rich variety of intensity in hue and saturation, brightness and darkness. Such resulting ephemeral aspects lend the architecture and its environment with ambiguity, fragility, evanescence and uncertainty. Some examples from Japan and La Guyane also show recent efforts in the search for enigmatic expressions of colour and light interacting in architecture and urban space.

In contrast to the relatively rare investigations exploring daylight, research and projects developing and applying new technology and understandings using artificial colour-light environments, e.g., so-called 'interactive' installations, are becoming a major trend, commercial tool and media-driven obsession. Often irritating the senses such applications are now commonly experienced as part of urban life in the form of commercial actions and temporary event-oriented installations, e.g., White Nights, Festivals of Lights, New Year's Eve celebrations and other mass events performed in public space. The commercial – or entertainment – touch calls for rapid change effects and intense, short interventions: slick advertisement and fashionably fun are combined in the tradition of Las Vegas. As a result urban space is de-constructed visually to the extent of annihilation as a media-imposed stage for fluctuating screens rather than background and platform for human presence and exchange. Often architecture façades are used as huge screens for gigantic performances. However, some contemporary architects, e.g. Jean Nouvel in collaboration with lighting designer/artist Yann Kersalé or artists, e.g., James Turrell are calling for a more subtle way of using the newly developing lighting techniques and technologies. One of the main ways that artificial lighting affects colour and shadow is to radically reveal – and transform – the relationship between volume and void, both enhancing and blurring contrasts. Understanding and dealing with a range of human senses are essential in artistic light-colour installations, some of which elude boundaries between the real and unreal to establish a disturbing ambiguity, a paradoxical consolidation of the two states that can surprisingly even sometimes produce a pleasurable spectacle.

# Painters judging brightness of coloured samples under chromatic illumination

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## Abstract

The objective of this experiment is to examine appearance of coloured surfaces and mood variation under several chromatic lights. To anticipate appearance of surface colours different light conditions is of importance for painters and colour-designer. Their task is to design and apply colours in the built environment. An aim for their education is to strengthen their awareness of the impact of light conditions on perception of colours. Colour conditions tested were of rather extreme nature, featuring saturated chromatic lights. The experiment was performed with students of craftsmen painters and colourdesigner.

The experiment described took place in a classroom that was equipped with fluorescent tubes to provide light with a variety of spectral power distributions. Achromatic as well as chromatic lighting conditions were provided. The room was lit by 120 ceiling mounted luminaires. The room with white walls and a dark grey floor did not receive any light from the darkened windows. Following hues were tested: red, green, blue, cyan, magenta and yellow. In one session achromatic light was provided. The experiment involved 7 sessions spread over 7 weeks each lasting 1,5 hours. The students had 90 minutes to complete four given tasks. This paper focuses one the task that required to fit four coloured samples according to their apparent brightness. This sorting task was repeated seven times under different lighting conditions. Each student did the exercise individually. In total 35 students between the age of 15 to 21 years participated in the experiment. The results of the experiment were compared with the hypothesized ranking derived from measured luminances. It showed that the positioning of the coloured samples in reference to grey samples varied in systematic order. The expected shifts that samples with hues similar to the hue of the illumination appear relatively brighter than samples with not similar hues were observed. For complementary colours some specific differences in perception were evident. Another part of this study was assessment with the mood state questionnaire; the students were asked to fill out a form before and after each session. It showed that cyan light in comparison to white light made the students more awake and green light caused a somewhat better mood.

Overall the experiment mainly confirmed the impact of lighting on appearance of coloured paint samples as it could be expected. But it additionally indicated that working under coloured light conditions can cause mood changes and hence needs to be considered.

# Chromatic enlightenment: Color and light in modernist religious architecture [a spiritual journey in two buildings]

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## Abstract

This paper develops a case-study comparison of the implications of the manipulation of color and light in two modernist religious spaces:

Annunciation Monastery (formerly Annunciation Priory) | Bismarck, North Dakota.
Marcel Breuer, 1959-1963.

Mount Zion Temple | St. Paul, Minnesota.
Erich Mendelsohn, 1950-1954.

The religious building is a genre typically designed to invoke heightened spiritual experiences. The congregational areas of the buildings presented here – chapel, church, and synagogue spaces - house the worship of a variety of religious practices and beliefs. Rather than deconstruct and identify use of colors in relation to religious symbolism, this paper explores the phenomenological effects of manipulation of color and light. Here, we examine how a color and light experience can help to convey the ideas, attitudes, and emotions underlying devout practices.

The research was primarily conducted through visual and spatial experiential investigation. Particular attention was paid to color and light in relation to ritual. This required site visits and/or architectural vacations to experience the sites in the appropriate conditions (and also allowed for conversations with those that use the spaces!) Therefore, each site was experienced more than once in the late winter/early spring season during the times of day when a religious service does or may likely take place. Published material was used to supplement the on-site research.

Both architectural teams employed a mix of methodologies to create color and light moments. In context of the spiritual spaces, the paper exposes techniques of use of color and light for **advertising**, **awe**, **direction** (both literal as wayfinding and metaphysical as conduit to higher powers), **grounding**, **intimacy**, and **intimidation**. The paper identifies how the use of light and color as design elements can significantly sway the meaning of the experience of the religious practice in the identified spaces. Furthermore, the paper illustrates how areas, as "color containers", hold and convey ideological thoughts and attitudes and explores the methodologies of the modernists as a gateway to contemporary innovations in use of color and light in religious spaces.

# Estimation of spectral reflectances of an art painting using a multispectral camera and evaluation of their accuracies

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## Abstract

Digital archive of art paintings is a promising technology to leave them as our human heritages to the future as if they were painted at the present time. The impression of an art painting changes largely with illuminations. In order to reproduce realistic color images of the painting under a variety of illuminations, the spectral reflectances of it must be accurately recovered at the spatial resolutions of a camera pixel. It is usually desirble to recover the spectral reflectances without the prior knowledge of it.

Usually colors in a painting are not uniform in the two dimensional space, which is quite different from that of color charts, therefore colors are not uniform within the area used to measure the spectral reflectances by a spectrophotometer and the area contains many pixels within it. So, it is very difficult to evaluate the accuracy of the recovered spectral reflectance of an art painting. This paper describes the experimental results on the comparison between the measured spectral reflectance by a spectrophotometer and the mean spectral reflectance recovered by the pixels within the area used for the measurement.

The Wiener estimation is widely used to recover the spectral reflectances of imaged objects by using image data. However the recovery performance of it depends on the noise present in the image acquisition system and on the spectral reflectances used for the autocorrelation matrix. We used training samples of the Macbeth ColorChecker to estimate the noise variance and also used spectral reflectances of the samples for the autocorrelation matrix. A seven channels multispectral camera was used for image acquisition and three different types of art paintings, a watercolor painting, an oil painting and a Japanese painting drawn with natural mineral pigments, were used for image acquisition.

From the experimental results it is shown that the accuracies of the recovered spectral reflectances of an art painting must be evaluated by averaging spectral reflectances recovered by the all pixels within the area used to measure the spectral reflectances by a spectrophotometer.

# The real and the ideal fashion image type and the color image favored by contemporary Korean women

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## Abstract

The purpose of this study is to classify the real fashion image and the ideal fashion image favored by Korean women in their twenties and thirties, and to find out the standards and the color features that divide such a classification.

For this study, we used the Q method, which is valued as an effective way to find out asses subjectivity, for the collection and the analysis of materials, in order to objectively classify the perception of and response to the fashion image. The subjects of this study were 60 women and all of them resided in Seoul. For the survey, fashion image excitant are composed of 88 fashion images which best reflecting Korean women's fashion in their twenties and thirties. We collected the Q response materials by showing the Q sample to the subjects, and performed the Q factor analysis using the PC-version of the QUANL program and SPSS 15.0 statistics program. The analyzed materials were classified into 12 fashion image types in total and we named each type of the fashion images and analyzed the features and the color images of each fashion image type through the in- depth Q workshop in which 14 professionals participated.

The following is a summary of this study. First, the real fashion image type was minutely divided into six fashion image types, that is, 'Basic Casual', 'Vintage Performer', 'Easy Chic', 'Ladies' Look', 'City Office Girl' and 'Club Mania'. Second, the ideal fashion image type was also divided into six fashion image types: 'Power Fashion', 'Fashion Conservative', 'Semi-culture', 'Fashion Otaku', 'Sweet Darling' and 'Fashion Panic'. Third, the color feature that represents the fashion image was classified as follows. The representative color of the mainstream fashion image was in many cases monotones such as black, and the tone of the color had high frequency in purple-blue and purple lines and deep and dark grayish tones were highly exposed. This fact illustrated that the refined and professional features manifested themselves as monotone and the calm image was expressed with cold color. The representative color of the nonmainstream fashion image was not monotone had a high frequency of warm color like yellow red, yellow and red purple, and focused on bright and vivid tones.

This study clarified fashion images were classified into types that can be objectively perceived, and found out that color is a medium of common sensitivity with which human beings perceive and express images because the recognizable features of color image were distinctively divided by each fashion image type.

# Observer metamerism potentiality of a metameric pair

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## Abstract

Observer metamerism is defined as a property of a pair of spectrally different stimuli having the same colour sensation for an individual (reference) observer. Frequently, samples in this pair no longer match if the observer is changed. As the value of "metameric" colour difference $\Delta E_{observer}$ is test-observer dependent, the aim of this paper is to define a new general, test-observer independent measure for the total degree of observer metamerism, a general measure for the ability of a metameric pair to exhibit observer metamerism. This single-number quantity is called *Observer Metamerism Potentiality* (OMP) of a metameric pair. Although the value of the OMP is independent of any particular deviated observer, it still provides a close link to the maximal magnitude of the metameric colour difference (*i.e.*, to the maximal $\Delta E_{observer}$). In this regard, OMP can well be used for mutual comparison (of the degrees) of observer metamerism for different metameric pairs.

To this sake, a linear approximation formula was developed which links an arbitrary (small) observer CMF-change to the colorimetric shift of a reflecting sample. The application of the developed equation to a metameric pair of reflecting samples gave another linear approximation formula, which transforms an arbitrary (small) change $\Delta\vec{x} = \Delta\vec{x}(\lambda)$, $\Delta\vec{y} = \Delta\vec{y}(\lambda)$, $\Delta\vec{z} = \Delta\vec{z}(\lambda)$ of observer's colour matching functions $\vec{x} = \vec{x}(\lambda)$, $\vec{y} = \vec{y}(\lambda)$ and $\vec{z} = \vec{z}(\lambda)$ to the truly-metameric effect ($\Delta L^*$, $\Delta a^*$, $\Delta b^*$ – the colour difference vector between the colour positions of metameric samples under the deviated viewing condition where the observer's CMFs had been slightly changed. This latter approximation formula enables us to define the above mentioned *Observer Metamerism Potentiality* (OMP) of a metameric pair.

The results of numerical experiments are presented in which we investigated the correlation between OMP and the maximum of 18 metameric colour differences $\Delta E$ caused by particular changes from CIE Standard 10-degree Observer's CMFs to the CMFs of the 18 real 10-degree observers (Wyszecki & Stiles: Color Science. pp. 817-821)). Typical results are illustrated by the analysis of metameric spectra-packages of four Munsell chips. Although a reasonable correlation between OMP and the maximum of CIE observer-metameric colour differences $\Delta E_{observer}$ was generally found, it should be pointed out that constructing a linear regression system between *OMP* and the average $\overline{\Delta E_{observer}}$ is not the matter of concern. Another important subject of our interest was to determine an upper-bound for "observer-metameric" colour difference $\Delta E_{observer}$ that can be exhibited by a given metameric pair under any particular from the set of considered test observers. The inequality to calculate such upper-bound is presented.

# Color configurations of Jaipur palaces

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## Abstract

Color is a vital element in architecture and design. It informs and speaks to us in various ways, gives expressions to spaces and enhances its visual language. The research aims to identify color shades on the exteriors and in the courtyards of the palaces in Jaipur. The semi autonomous state of Rajasthan and its political capital Jaipur has creatively used color in the parched landscape which is elaborately demonstrated in its traditional palaces. The exterior color is a gesture of the building and courtyards are the most interactive and festive spaces. Hence, five important palaces are chosen for the color assessment. The hot and dry climate of Rajasthan with its architectural style comprising of open and semi open spaces receives optimum stark daylight. The premise of the study is confined only to the assessment of perceived colors of the palace buildings in natural light and does not include the study of inherent color or the application techniques and methods. The focus is to unfold the attributes of use of colors in the palaces that have created the resulting color configurations. It creates a rationale of colors and factors governing the relation between hues, expounding their play in the palaces of Jaipur.

The colour assessment for perceived colors is carried out by using NCS fan deck of 1,950 color shades as a visual match done by overlapping the samples on the surface of the buildings. It is done in the month of March 2010 in between 10.00 a.m to 5.00 p.m. The colors are analysed with respect to NCS as well as on the basis of the attributes of its use in the painting tradition. These color shades falls in a similar group of color families, largely in the yellow to red (Y-R). The range of all the colors recorded shows the exact percentages of their components. In Jaipur color is bound with local cultures and their rationale demonstrates that they are pastel in character. It has created a detailed description of the kaleidoscopic display in the palaces scientifically as well as culturally.

The study can be used for the conservation of these palaces in Jaipur in present and in the future. In todays context, the derived rationale of the entire colour palette proves to be of a potential use for designers of various domains, architects and craftsmen, not only in India but internationally.

# The psychological and physiological effect of 'Cool Down Pink' on human behavior

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## Objectives and scope

The aim of the research is to prove that colours have influence on people. Using the sample of Cool Down Pink a physiological effect, which leads to an adaption of the human behaviour could be proven. The effect is primarily neuropsychological. Scientifically this topic belongs to the subject of neuropsychology.

## Description of the methods

To confirm the results a methodical triangulation of the subtype across-method with the standardised colour Cool Down Pink was used:

– Measurement of the blood pressure and pulse rate on entering and leaving the colour cabin;
– Observations of the behaviour change in aggressive prisoners when confined in Cool Down Pink cells in the form of an unstructured, hidden and non-participating observation as an explorative knowledge generating method of evaluation.

The results for the Cool Down Pink effect achieved through various methods showed a correlation and increased the validity of the research.

## Summary of results

Statistical evaluation of the research in the colour cabin showed highly significant results. As well as the systolic, the diastolic blood pressure significantly decreased in the Cool Down Pink cabin within 1-5 minutes.

In the high security section of the prison at Pfäffikon ZH, Switzerland four cells in Cool Down Pink have been installed since 2007. In these cells only prisoners with an especially high aggression potential are confined. According to the statement of the prison's director the aggressive behaviour of these prisoners has been greatly reduced. It has also been observed that the aggressive prisoners calm down much more quickly in Cool Down Pink cells in police stations than in the white cells and that they can return earlier to the normal police prison. Negative behaviour changes or side effects were not observed. Suicide risk or pent-up aggressions have never been observed or established.

## Main conclusions

Statistical evaluation of the data in the colour cabin showed highly significant results and the effect depressing the blood pressure was confirmed.

Caused by the rapid effect on the vegetative control mechanism, Cool Down Pink can successfully be used as a low threshold intervention instrument for the control of aggression in penal institutions.

# Misconceptions about HDR photography

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## Abstract

A general problem in photography has always been how to capture real world scenes which contain the range of luminance that considerably exceeds the dynamic range capabilities of camera (i.e. film or sensor) and output media (monitor, print). Conventional photographic materials, as well as digital image sensors cannot match the dynamic range of a scene, and can only capture a subset of luminance present. One of the techniques which try to resolve this problem is the High Dynamic Range technique. There are two aspects of creating HDR image: capture of an HDR scene with conventional (LDR) photo camera by taking several different exposures of the same scene and merging them into a single HDR image, and second, reducing the dynamic range in an HDR image to produce a meaningful image on a monitor or print.

Although the idea is not new; its wider usage started just a few years ago with the rising popularity of digital cameras and the increase of computers processing power. Now this technique is widely spread and used, but more often - misused. The problem HDR technique faces nowadays is not a technology problem, but the problem of misconceptions and bad public impressions of it. It is a solid technique, but often used for wrong reasons and in a bad manner. This paper deals with the impressions of HDR photography among photographers.

The research was conducted, using a questionnaire, to get some actual information about how Croatian photographers see the HDR photography and how they employ it. The questionnaire was e-mailed to the respondents using the mailing lists of professional photographers from the Croatian Association of Artists of Applied Arts (ULUPUH) and the three largest photo clubs in the country. More than a hundred replies arrived and were later classified into professional and amateur group. The results of the questionnaire proved that indeed a great interest exists in the technique, but that many photographers are scared away from HDR photography because of the misconception that the artificial look is an unavoidable side effect of the HDR processing. However, the fact is that the final HDR image is a result of the tone mapping process and post-corrections and adjustments, entirely dependent on photographer's intent and vision, as well as his understanding of various adjustments available. The results of the questionnaire have also pointed out other widely spread misconceptions which are discussed in this paper.

The main conclusion from the conducted research is that creating a good HDR photography is a technique that has to be learned. As with all new methods and techniques, there is obviously an evolution of use. Photographers first experiment (often use to extreme) and eventually, with time, gaining the experience and knowledge how to settle on a more subtle and refined final images.

# Yellow-blue colour discrimination in red-green colour deficiency

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## Abstract

The protanopes and deuteranopes are well known as red-green colour-deficient person because they hardly discriminate between red colours and green colours due to lack of L cones or M cones. The colours which protanopes or deuteranopes perceives are restricted in yellow-blue colours, according to the colour appearance of a unilateral deuteranope (Graham and Hsia 1958). The dichromatic simulation proposed by Brettel et al (1997) is based on her colour appearance. In their simulation, the property of yellow-blue mechanism of protanoupes and deuteranopes has been assumed to be the same as that of trichromats. Here, we measured colour discrimination thresholds in the equal-luminant plane of the CIE1976u'v' UCS for red-green colour-deficient persons.

The stimulus was generated by a high colour resolution graphic board and displayed on a 17-inch colour CRT monitor. The stimulus consisted of four rectangles with a large background. The four rectangles were arranged in 2×2. The sizes of each rectangle and the background were 1.4 deg and 20.6 deg, respectively. There were black gaps of 0.2 deg in between the rectangles and the background. The u'v' chromaticity of the four rectangles and the background was (0.1978, 0.4683). The luminance of them was 8.0 cd/m$^2$. The stimulus was presented to an observer in a time course as follows. The four rectangles disappeared for 75 msec. And then, the four rectangles appeared for 150 msec. In this period, the colour of one rectangle was shifted to one of 16 directions in the u'v' chromaticity diagram, maintaining the constant luminance for individual observer. The colours of rest rectangles did not change. The four rectangles disappeared again for 75 msec, and then they appeared with the D65 chromaticity. The observer's task was to respond the position of the rectangle whose colour changed. Two trichromatic observers and three red-green colour-deficient observers (one protanomalous and two deuteranomalous trichromats) participated in the experiment.

The trichromatic observers' colour discrimination thresholds showed the shape of ellipse, whose major axis was along the v' direction. On the other hand, the major axis of the anomalous observers' ellipse accorded with the protanopic or deuteranopic confusion line through the D65 chromaticity, respectively. Since the colours used in the dichromatic simulation are yellows of the dominant wavelength of 575 nm, blues of the dominant wavelength of 475 nm, and achromatic colours, we compared the thresholds in the directions of 475 nm and 575 nm between the trichromatic observers and the colour deficient observers. Although the thresholds in the direction of 475 nm were nearly equal between them, the thresholds for the colour deficient observers in the direction of 575 nm were larger than those for the trichromatic observers. Therefore, these results suggest that the contrast of yellow in the dichromatic simulation should be decreased to demonstrate colour appearances of dichriomats more accurately.

# Development of simple color bipartite apparatus using single light source with LEDs and measurement of individual color matching functions

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## Abstract

Individual variations of color matching functions (CMFs) cause observer metamerism. If we could use individual CMFs data, it would allow us to evaluate the degree of color mismatch between a test observer and the reference observer. However, it is not easy to obtain individual CMFs. Some of the difficulties come from the complexities of the optics system which is used to measure CMFs. In the present study, we developed a simple and compact bipartite apparatus with a single light source consisting of time-controlled monochromatic LEDs, and measured individual CMFs.

We used a single light source, in which plural LEDs were inserted to a small integral sphere (6'' diameter). A beam splitter splits the light from the integral sphere into two optical paths; a test stimulus path and a reference stimulus path. Each optical path was alternately blocked off by a rotating optical chopper. Depending on the position of the chopper blade, only one of the test or the reference stimulus was presented to the observer. Moreover, the switching timing of the LEDs was controlled to synchronize with that of the optical paths. It was possible to arbitrarily choose any combinations of the LEDs to be presented both to the test and to the reference stimulus area. As for the switching frequency, we adopted 100Hz in the experiment. This was high enough for the observer to perceive the stimulus to be continuous. The intensity of each LED was controlled by changing the width of the pulse signal what was provided to drive a LED. The apparatus was compact and simple. All the optical parts were placed on a small breadboard (450mm (17.5'') x 300mm (11.7'')).

In order to match a color of the test field to that of the reference field, subjects adjusted the intensity of three primary LEDs (red, green, and blue) by operating a controller. Twelve different LEDs including three primaries were installed to an integral sphere. LEDs with the peaks at 626nm, 524nm, and 472 nm were chosen as red, green and blue primaries, respectively. In the preliminary experiment, the luminance of the stimulus was set to 2 cd/m$^2$, which corresponds to approximately 80 td. The CMFs were obtained from four subjects in the preliminary experiment. We could see individual differences in CMFs. Further measurements are also scheduled to collect data from many subjects in order to build the database for the individual variation of the CMFs.

# A color analyzing tool "SciColor" for research and education

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## Abstract

This study concerns a color analyzing tool "SciColor" for color in images.

In research and education of color science, it is essential to handle information of color and image quantitatively. For our former researches, we developed and used two software tools "SCIRA" and "Colorcel" for quantitative analysis of spectral data, color data, and color images. SCIRA is a kind of program library for information processing of color and image. Users can handle an enormous number of color images precisely. However, skills of computer programming are required to use SCIRA. On the other hand, Colorcel is an interactive analyzing tool for spectral data and color data which is very easy to use. It is implemented as an add-in software for Microsoft Excel. Colorcel does not have functions to handle images.

SciColor is an evolved tool of Colorcel. Color image processing functions are appended to SciColor from SCIRA. Features of SciColor are listed below:

1.  It is implemented as an add-in software for Microsoft Office (Excel and PowerPoint). High-level skills for computer operation are not required.
2.  Spectral data and color data are listed in Excel sheets directly. On the other hand, color images are stored in external files, and links to these image files are stored in Excel sheets.
3.  ColorDat: Fundamental constants, for example, color matching functions, spectral locus, spectral data and chromaticity values of several illuminants, etc. are supplied by Excel data in worksheets.
4.  ColorCalc: It provides a number of user defined functions and interactive tools for calculation as well as analysis of spectral data and color data.
5.  ColorView: It makes graphs of colors which are mutually related on several kinds of color spaces. Excel graph sheets or PowerPoint slides can be chosen as canvases of output graphs.
6.  ImageCalc: A set of external programs for analyzing color images are supplied. It includes mosaic image maker, quantization of color values on pixels, color value conversion on pixels, several kinds of filters, and calculation of fundamental statistical characteristics of images. Users can describe a combination of these programs as a catalog in an Excel sheet.
7.  ImageView: Visualization of color images is available. A function to pick up color values of specified points is also supported. Same as ColorView, Excel graph sheets or PowerPoint slides can be chosen as canvases of output images.

Analysis and visualization are carried out alternately in research and education of color science. Visualized results of analysis give us new hints for succeeding analysis. SciColor assists quick and smooth continuation of our operation.

# A color preference model for different color appearance modes

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## Abstract

Color preference, although, has been investigated since the early times, it remains a source of debate among the public in many fields such as sciences, designs, advertisings, marketing, fashions and so on. 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 the color appearance mode. In our daily life, colors are perceived not only as an object color mode, but also as other modes such as an unnatural object color mode and a light source color mode. The major aim of this work is to develop color preference model on the basic of the perceived color attributes for different color appearance modes.

In our previous study, thirty-three color chips were presented in different color appearance modes by changing the intensity of the environmental illuminance and the test chart luminance. The experimental result expresses that color preference varies according to the color appearance mode. It changes a lot in the object color mode and a little in the unnatural object and light source color modes. Since a change in the color appearance mode of color chips causes a change in an amount of the perceived color attributes, the relationship between color preference and the perceived color attributes was investigated. The perceived color attributes were collected from the elementary color naming. According to results, color preference significantly relates to the perceived blackness in the object color mode, while it significantly relates to the perceived whiteness in the unnatural object color mode and light source color mode.

The empirical evidence indicated that the perceived color attributes as well as the color appearance mode played important roles in color preference. This study, hence, was carried out to derive a color preference model. Even though the color preference models have been proposed, these existing models were not developed on the basis of the perceived color attributes. Furthermore, these existing models may be ineffective for predicting colors in the other modes. In this study, the results of the color preference score, color appearance mode, and perceived color attributes were obtained from twenty-four color chips presented under six conditions. The color preference model for different color appearance modes was proposed. In this model color preference could be predicted by the perceived blackness, perceived whiteness, perceived chromaticness, perceived hue, and color appearance mode index. This model is a new possible method for quantitatively predicting color preferences in three color appearance modes without using colorimetric measuring instruments and provides a reliable platform for the future study of color preference.

# Colour-shape interaction analysis of the post-Byzantine nave decoration in the Church of the Nativity of Christ, Arbanassi, Bulgaria

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## Abstract

The aim of the paper is to assess how the compositional patterns of the wall paintings in the nave of the post-Byzantine Church of the Nativity of Christ interacts visually with the architectural structure. For that purpose different sections of the interior were examined and account of the interior lighting was taken.

Although the existing research developed understanding of the use of colour in this particular post-Byzantine monument, nevertheless it took colour out of its compositional and spatial context. The present examination bridges this gap by employing the conceptual frame of *Colour-Shape Interaction Analysis*. Such analysis assists in revealing how colour design interacts with the visual appearance of architectural shape, using three concepts developed from camouflage theory for application in an architectural context: counter-/coshading, disruption and constructive shading.

This investigation uses a method based on the visual analysis of the different key sections of the nave. The examination indicated: firstly, that the light arches carrying the roof appear more as symbolic than real because of the contradictory use of shape-enhancing *co-shading* with shape-obliterating *disruption constructive shading*. Secondly, the red grid between the scenes painted on the vaults is visually raised, by the constructive shading of dark and light contour lines. Each rectangle of the grid frames a composition of strongly contrasting fields (white, yellow, bright red and green, and dark blue), working on its own as a *disruptive* pattern and breaking up the continuity of the smooth surface. Best part of the compositional arrangements of the decoration of the nave also a constructive shading suggesting either coffering or shutters open to the sky.

Our investigation found that in the post-Byzantine nave decoration of the Church of the Nativity of Christ in Arbanassi, Bulgaria the colour design of decorative motifs and figurative compositions work together to dematerialise functional beams, transforming them into symbols, while the plane of the ceiling gains indeterminate depth. Such use of colour helps creating illusionary realities that manifest the fleeting nature of the present material reality. The result is an exuberant interior space, in which the heightened visual experience would have been intended to convey to the beholder a transcendent understanding of the metaphysical reality of the Heaven.

# Blue colour and light in architecture

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## Abstract

Blue, as the color of water and sky, is always present in landscape, creating background for architecture. Blue is also in many tests chosen as so call "favorite color."

In the paper author presents use of blue color in architectural space – in history as well as in contemporary design, considering its symbolic, functional and decorative aspects, composed in four thematic sections:

**Blue pigments:** Blue pigments have a long history. Among them one can find the Maya blue pigment; azurite; vivianit - called also blue iron earth or blue ochre; Egyptian blue - considered to be the first synthetic pigment; Natural Ultramarine having been the most expensive pigment and Prussian blue - first modern, artificially manufactured blue color.

**Blue color symbolism and meaning:** In many different cultures blue is associated with eternity, spiritual and intellectual life, thus being the attribute of many gods. In many regions of the world blue color is used on window frames and doors, what may be connected with folk belief of keeping misfortune away by so called "blue eye" or "blue bead". So, blue or bluish hues were probably used to protect the house, people and animals against evil.

**Blue color traditions:** There are some blue color traditions throughout the world which are very unique. One is that of city Jodhpur in India, called "Blue City", another tradition is connected with Poland, where blue color was commonly used for wooden houses colorization in the second half of the 19th century.

**Blue color and light in contemporary built environment:** In modern times blue color in usually present in architecture due to the glass facades, which reflects bluishness of the sky. In case of high buildings and constructions visible on the sky background, blue is sometimes used for camouflage. However, buildings painted completely blue are still not very popular, and are usually strong contrasting with its surroundings. Blue light appears e.g. in architecture of media facades as well as in buildings illumination, being one of the three primary colors in RGB led structure.

**Conclusions:** Blue color is not very often used in architecture, especially as primary façade hue. In ancient times blue was so rarely used, that some researchers supposed, that antique people can't evolutionary recognize it. However, main reason for this, was that naturally occurring blue minerals are rare and therefore blue pigments were usually very expensive. That fact, together with blue symbolism connected with heaven and spiritual world of gods, caused that even today blue in architecture has special, mysterious position among other hues.

# Chromatic study of the architectural work "La Muralla Roja" by Ricardo Bofill

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## Abstract

La Muralla Roja is located in the resort of La Manzanera (Calpe-Alicante). This building is the modern architectural reference work concerning the application of color in Spain. It is one of the first to consider the color in the global project. The project began in 1968 and finished the construction in 1972.

We are confident that its location is a reference for the application of color in modern architecture.

In La Muralla Roja, however, space and character are treated in a more general way, without losing the necessary reference to the locality. The name already suggests this relationship; being conceived as a "muralla", the building serves as a "wall" in the landscape, which visualizes its structure and character through simultaneous adaptation and contrast. Adaptation is here achieved by means of subdivision and articulation of the mass, whereby a relevant spatial rhythm is created, whereas contrast is mainly due to the use of color. The red exterior thus contrasts with the surrounding rocks and vegetation, at the same time as it constitutes a focus which gives presence to the heat of the sun. The blue courtyard offers a refreshing complement.

The aim of this study is to assess the perception of color in La Muralla Roja (one time at 12 h sun hours), depending on their orientation (North, South, East and West) and faced landscape (sea-blue, forest-green and red editions and blue).

We have placed 6 pairs of points to measure the influence of the landscape and the height variation of the chromaticity coordinates. These points are marked on the wall to measure always the same points.

We can not give the final conclusions until we finish the period of measurements, we have in mind that some of these variations may be due to the paint and some accidental situations (traffic, pollution ...), apparently east-facing area (sea + sun) is the most impaired.

If the measurement variation of both points is similar, we understand that the whole variation is due to the influence of the landscape (orientation, sun, sea, forest, color of the facade ...).

# Learning and teaching color as a multidisciplinary topic based on scientific knowledges and artistic concepts

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## Abstract

Art and science are actually largely different from each other, although there are many interesting things to learn from either side. Color as a science seems to have been relegated for many years in art, design, architecture, and media education. The objective of this paper is to bridge the gap faced by scientists and designers when teaching color and to enhance the interest of color for learning, teaching and research in the Art and Design education but also in Computer Vision and Computer Graphics education. The main objective of this paper is to show how the Erasmus Mundus master program CIMET (Color in Informatics and Media Technology) contributes to bridge this gap and to show how the foundation skills, the learning outcomes, the topics taught, the teaching methods, the assessment criteria, etc. used in this scientific master program could be extended to other scientific and non-scientific master programs. CIMET offers three areas of specialization: Color Imaging Science, Spectral Color Science and Multimedia Technology Science. We will show through the example of the *Color in Art and Design* course how some artistic concepts (e.g. color symbolism, color harmony, color emotion, etc.) can be taught to scientific students and how subjective concepts can be formalize as objective concepts.

That is, teaching theoretical courses that require the understanding of many mathematical models and equations to students who do not have a strong background in mathematics is always challenging. Identifying the students' learning style preferences and considering them in the design of learning and teaching packages can be a right solution. In the CIMET master, we tried to minimize the time taken in conveying the main message of each topic and to maximize their desire to learn and to some extent their enjoyment to learn. Thus, first we encouraged teachers to use multimedia systems in complement (not as a substitute) of traditional teaching/learning methods. That is, in some courses videos, animations and menu items do not necessarily add value. In other course, such as *Color and Art and Design,* interactive materials stimulate further interest in the relationship between *Color Science* and Art. Several websites are very rich sources of data and of explanations to talk about color, to understand color theories, to apprehend visual color relationships, etc. Mediums such as optical illusions are also essential to convince students of what they are told because they see by themselves. Lastly, 3D Virtual Reality is a powerful tool to illustrate how the concepts of color space and color order systems are essential to analyze, to model, to understand a work of art but also to characterize the spectral response of a piece of art or to interactively test in real-time different hypothesis on spectral reflectance data.

# A study on perceived colours of façades under different light sources

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## Abstract

The aspect of "facade colours" is an inseparable part of architecture and one of the vital elements for creating meaningful, expressive, discernible architectural environments. Therefore, colours and colouring are important for description and formation of the identity of a region /settlement/ city. The improvements in technology and the increase in the number of artificial light sources make possible to select and use any source in any colour nowadays. With this progress many lighting designers have started to use coloured sources for facade lighting to create different visual impressions. But it is obvious that lighting by coloured sources will cause the facades to appear different from the original designs of the architects. Due to this fact, prediction of perceived colours of the facades under different light sources has become an important issue in terms of city lighting and night appearance of the cities and buildings. In this context, prediction of the changes in colour appearances caused by the light will help to create appropriate lighting designs and to prevent unexpected colour appearances or effects in terms of the facade colour design.

This paper aims to determine the perceived colours of different facade paints under different light sources, to reveal the changes in facade colours and to present the beneficial data for facade lighting designers.

The basic steps of the study can be explained as; identifying the colour properties of different light sources that are widely used in facade lighting, determining facade paint colours widely used in Turkey, measuring the spectral reflectance distributions and the inherent colours of the chosen paints, calculating the perceived colours of the chosen paints under different sources of light considering human visual system and finally determining the difference between the inherent and perceived colours of the paint colours. In this context, three gas-discharge lamps (high pressure mercury lamp, metal halide lamp and sodium lamp) and four LEDs (blue, red, green and white) having different colour quality, totally seven light sources and two colour arrangements (same hue, hue contrast) having two different colours, totally four colours were used in the study.

The evaluation demonstrates that in the perceived colour of surfaces the value component (lightness-darkness) generally does not change. However it has been identified that in the hue and chroma components there are important deviations from the inherent colour. As a conclusion, the colour arrangements created do not maintain their arrangements qualities under sources of light used in the study.

# Colour Edu.System: A creative and systematic approach to colour education in design

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## Abstract

Colour complexity is represented by many relationships and often overlaps among different disciplines and market fields that, today more than ever, are able to increase its interdisciplinarity. This is the main reason why it is still difficult to create a real shared colour knowledge, and consequently a common language that permits the simple comprehension and application of colour notions, and the creation of innovative contaminations.

To ensure the successful development of a colour culture, it is essential to educate the importance of colour at a young age. This will encourage an independent approach to complex issues relating to colour in design at higher education.

After a brief investigation of colour education offered within European design schools, and a survey conducted at the Faculty of Design in Politecnico di Milano, interesting, and concerning, results of BA degree level students' colour knowledge became apparent. Consequently this PhD research is concerned with creating a didactic model which can support both colour learning and teaching in the design field through a creative and systematic approach. Colour awareness and colour as a design component would be encouraged.

The action research methodology is permitting the testing and analysis of some didactic activities through the use of special metadesign card decks, designed for the first workshop circumstance at École Nationale Supérieure des Arts Visuels "La Cambre" in Bruxelles. The ongoing experiments using the metadesign cards will also be tested at the School of Design of the University of Leeds and at the Design Faculty of Politecnico di Milano. Modifications will be made in conjunction with the results. This is due to the iterative process of the chosen methodology.

The current results have confirmed that students have some difficulties in applying their theoretical colour knowledge, during the design process.

Their difficulty is in managing colour complexity in a systematic way, finding connections across different disciplinary fields. The choice to use card sorting, and carrying the tasks out through teamwork discussions, has favoured their curiosity and involvement in colour research and design complexity mapping.

The next generation of designers must be equipped with complex design skills, and a comprehensive understanding of the importance of colour in design, in order to successfully cross collaborate with other disciplines. This will encourage innovative and conscious design decisions.

# Vectors of development of folk dwellings coloristic formations of Europe (time and geographical aspects)

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## Abstract

Polychromy of architectural and spatial environment in modern folk architecture is changing towards the growth in the number of colour carriers engaged in the formation of the architectural environment palette. Coloristic combinations start being applied in the folk housing architecture, the chaotic variety of colours of which totally endangers the specific features of traditional coloristic environment, regional peculiarities that had been formed through centuries.

Unfortunately, globalization processes are gradually destroying coloristic identity of folk architectural and spatial environment leaving repeatability and monotony deprived of deep spiritual content hidden in the coloristic specificity of folk art of dwelling decoration instead. The aim is to trace the vectors of coloristic formations development in the European folk architecture as well as the regular principles of their formation, development and transformation starting with the beginning of the XIXth c. and up till now. The task is to trace the main factors which influenced the development of coloristics in folk dwelling architecture.

The methods are as follows: study of literary sources, research of fine arts and photography materials which are directly or indirectly linked to the topic, research of the coloristics of available folk dwellings objects on location. Coloristic solution of the wall plane in folk dwelling architecture constitutes a product which is easier to apply if done using industrial dyes. Starting with this moment two basic factors of development of coloristic decoration of folk dwellings are pointed out: urban and local ones.

An urban vector presupposed direct borrowing and introduction of new coloristic solutions used in professional architecture, industrially manufactured decorative elements, artistic decorative materials which were appearing in the urban culture into the folk architecture. Not only were decorative and relief ornamentation of the facades of the Renaissance, the Baroque or the Modern interpreted but their coloristic solutions as well. A local vector of coloristic development in the European folk architecture presupposed interpretation of polychromy of ethnic groups, their decorative and artistic coloristic solutions by way of using industrially manufactured artistic and decorative materials appearing in the professional urban culture.

Local peculiarities of folk dwelling solutions were also formed within the areas of development of urban and local vectors of coloristic formation. Such tendencies are also maintained today, and where these trends meet there is some friction as well as sometimes mergers of vectors of coloristic folk dwelling decoration take place there. Color in folk building and its cultural and esthetic development is permanently in the process of further development and showing one's view of the new tendencies.

# The influence of backgrounds on mura detection in TFT-LCDs

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## Abstract

Mura is a type of defect on LCD's that affects image quality. Its subtle nature, consisting of gradual and non-uniform changes in lightness within a specific area, reveals that it is hard to detect by normal optical instruments, although our highly-sensitive visual system can see it relatively easily. For many years, researchers have approached defect measurement by proposing visual models to determine whether a Mura pattern is visible under certain conditions. Few have extended their investigations into the conditions in which Mura defects are viewed against complex image backgrounds. Research does not account for the reality that human subjects, who are capable of processing complex image content, would barely notice a Mura defect on their LCD displays.

In this paper, the influence of colour and background patterns on Mura detection is investigated. Method of adjustment was used to obtain the required psychophysical visual assessment data. The variables used in this experiment were the type (uniform, isotropic noise and grating), spatial frequency (0, 0.2, 0.4, 1, 2, 4 and 10 cpd), orientation (0˚, 45˚ and 90˚), background pattern colour (red, green, blue, yellow and grey), and size of the simulated Mura. Our analysis shows that the orientation of the Mura patterns has no effect for uniform and noisy background types, although some previous studies of visual acuity and contrast sensitivity showed an unequal sensitivity across orientations. The masking effect for spatial frequency tunings is significant for noise and grating backgrounds in which the spatial frequencies of Mura are close to that of the patterned backgrounds, i.e. 0.3 cpd for the large Mura and 1 cpd for the small Mura. This phenomenon also applies to grating backgrounds when orientation of Mura is close to that of background. The influence of colours is not as strong as the masking effect, but there is a consistent trend for both noisy and grating backgrounds that the JND values of these colours follow this order: yellow > green > red> light grey ≈ blue > dark grey. Mura size has a mild influence on detection when viewed against different backgrounds. The trend, however, is opposite to that found in previous studies conducted with uniform grey backgrounds. In summary, the JND values obtained in this study range from 0.5 to 2.5 $\Delta E^*_{ab}$.

Compared with previous research, our analysis shows that the masking effect dominates Mura visibility and is the key to reliable prediction during Mura inspection against different types of backgrounds. In other words, using Mura size as a unique index to predict visibility is no longer appropriate, particularly when the Mura is viewed against complex images rather than simple uniform backgrounds. The work is undertaken to develop a model to predict the JND by taking into account the parameters of colour, orientation and spatial frequency.

# Unsupervised colour segmentation of textile fabrics constructed by coloured yarns

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## Abstract

As the normal colour measurement method of using a spectrophotometer is impossible to measure colours of multi-coloured textiles woven or knitted using coloured yarns, commonly termed as 'yarn dyed' fabrics, colour measurement method based on the multispectral imaging technique is a viable alternative. To do this, a colour segmentation step is necessary. Few attempts have been tried previously due to the difficulties of colour image segmentation for yarn dyed fabrics. This study presents a novel approach of colour image segmentation of the yarn dyed fabrics. The colour images of yarn dyed textile sample in the perceptual colour space of CIELCH are reconstructed from spectral data captured by a multispectral imaging system with narrow-band filter channels. The proposed algorithm consists of three steps. A segmentation tree structure is firstly constructed by the unsupervised image content self-learning method which analyzes each histogram distributions and features of a colour image in each channel of the CIELCH colour space. In this stage, all local inflection points in the histogram are evaluated to segment the histogram distributions and a weighted cost function as a colour criterion is also calculated to effectively segment the dominant colour regions in each colour channel of the original image. Secondly, all colour regions in the colour image of the yarn dyed textile sample are segmented followed by a step of merging similar colour blocks to avoid over-segmentation. At this stage, a sorted sequence through searching of the segmented tree structure can be obtained. Finally, the spatial locations of the colour regions, which are used for the colour representation of these segmented regions, are established by the Hough Transform. Comparison was made to other image segmentation methods, i.e., region growing method and quadtree methods, using the same yarn dyed samples. The experimental results show that the new method is superior to region growing and quadtree method in terms of colour segmentation efficiency.

# Analysis on color perception characteristics of senior people by the method of decreasing color differences

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## Abstract

According to "The Sex and Age Distribution of World Population" published by UN, Korea is expected to carry into Aging Society(more than 9.0% of elderly population) in 2005, Aged Society in 2010(14%), and Super-Aged Society in 2026(20%). This is the most rapid aging progress in the world. Several studies have been performed to prepare such rapid aging society. In this study, we'd like to discuss about the color, and the interaction between color and light which is very important in visual information transfer for elderly people.

In this study, we made Mock-up model of real senior housing with changeable dimming, and made a interior color evaluation test according to the color of lighting, and then we checked the quantity of color shift of senior people through the color difference decreasing method, quantitative analysis method. Finally, we focused to find the appropriate indoor illuminance for senior people, according to the color of lighting, to decrease color perception error.

The analysis results of Color shift of lens filter Y2 (40-50 ages) and YA3 (60-70 ages), which are simulates crystalline lens according to the variation of the lighting conditions (indoor illumination, color of lighting) in interior space of elderly people, are shown as follows.

1. The lower illuminance, the bigger color difference between base colors of ceilings, walls and floors, and the object color formed by the lens filter. And, with the higher illuminance, color difference between base and object color was not affected significantly, and the difference of color shift of Y2 and YA3 lens filters were similar.

2. Daylight color above 4500K color temperature of the light, with the 850lux illuminance level, the color distance to standard color showed larger with using YA3 lens filter (60-70 ages) than Y2 (40-50 units). In case of bulb colors, under 3500K color temperature, it showed that no significant color distance between Y2 and YA3 lens filters.

3. Considering that Y2 lens filter represent the visual characteristics of 40-50 ages, 500lux of indoor illuminance with Warm(bulb) color lamp is desirable in a point of color shift. And YA3 represent for 60-70 ages, daylight lamp, over 850lux indoor illuminance, can be expected to reduce the color shift level of interior space.

# A research on the esthetic relationship of LED color lighting on products

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## Abstract

In the recent cases of LED lighting appliance, the colors are determined by the designer's intuition. Adding to this, due to the focusing on symbolic colors of companies and an indiscrete use of colors, a set standard for color usages is absent. Therefore, this research aims to extract the typical colors that will be used in electronic products and by analyzing the effects of those colors, find the esthetic relativity of colored lightings. The objective of this research is to study the esthetic relativity of colored lighting used on products. The research was divided into two significant parts: an esthetic evaluation and emotion evaluation. The first part was the selection of 9 kinds of colored LED lighting which had esthetic characteristics and the second was an analysis for the emotion evaluation of types of colored LED lighting. First, a LED lighting unit, adjustable to R, G, B colors, were tuned into 32 phases, extracting 710 colors, of which 9 were esthetic colored lighting. Second, the relationship between the colors was analyzed by conducting a quantity survey on the 9 types of colored lighting selected by an evaluation frame of emotional color words. As a result, upon comparative analysis on the value evaluation and image of color factor, it showed that the image of the color within the experiment that is not too strong or weak will receive high value evaluation. In other words, value evaluation will be low if the image of the color is too strong or weak. Second of all, upon comparative analysis on image of color and exposure frequency factor, no relation was found between the two. Finally, upon comparative analysis on value evaluation and exposure frequency factor, it showed that a low exposure frequency had a positive effect on value evaluation and a high exposure frequency had a negative effect.

# Gender differences in color and shape emotion

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## Abstract

The people communicate using language, shape, symbol, and color in daily life. A language is the most powerful, among those communication tools. However, when designer designs a product, non-verbal-language can be more effective to persuade customer. These days, people buy a product which design is mainly determined by „color" and "shape". Therefore, expressing emotional characteristic using color and shape is important in fashion and interior design field. Traditionally, color emotion researcher has been focused on color, without shape. Shape takes a role as a container. The same color can express different emotion when it is applied in different shapes, vice versa. In this study, effect of shape on total emotion is investigated. Also, effect of gender effect is considered.

Test stimuli are reproduced on the monitor in the dark room. Test shapes consist of 5 female garments and 1 rectangle. They were shown with black line on the grey background. Test colors consist of 10 single colors and 20 color pairs and 1 grey color. Totally, 186 stimuli are shown to observers. {(5 shape +1 rectangle) x (10 single colors and 20 pair colors + 1 grey background color) =186 stimuli} Then, Observers are asked to assess emotion of test stimuli using 9 bipolar affect adjectives; warm-cool, heavy-light, modern-classical, clean-dirty, active-passive, hard-soft, tense-relaxed, fresh-stale and masculine-feminine. 10 male and 10 female observers participated in this experiment.

As a result, color emotion assessed in rectangle patch is not significantly different between male and female($R^2$=0.80). However, shape emotion between male and female is considerably different each other ($R^2$=0.14). Male observers responded similarly, but female observers responded diverse between them. In order to identify the effect of shape on total emotion, color emotion evoked in the rectangle and total emotion evoked in the shape and color emotion is compared. In male's case, mostly total emotion is shifted toward shape emotion. This means, shape emotion is significantly affected on total emotion. While in female's case, even though shape emotion is diverse, also total emotion is shifted toward to each observer's shape emotion. In conclusion, regardless of gender, total emotion is shifted toward shape emotion.

# Gender differences in social perception for skin tones

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## Abstract

Skin tone plays an important role in image quality enhancement in the imaging industry. Existing studies mainly used real human face images as stimuli, without considering any impact of race, age, gender, facial feature or facial expression, all of which might affect the visual results. Thus the findings from these studies do not always agree with each other; it is also difficult from these studies to justify whether the results were based solely on skin tone or might have been influenced by other factors. To address this issue, the present study used 12 computer-generated face images to study impact of skin tone on the viewer's perceptions of attractive/unattractive, masculine/ feminine and cooperative/uncooperative. Twenty-nine British observers, 14 male and 15 female, participated in the experiment.

Responses of the two gender groups were first compared in terms of correlation, showing a correlation coefficient of 0.71 for attractive/unattractive, 0.35 for masculine/ feminine and -0.16 for cooperative/uncooperative. This indicates the two gender groups agreed well only on the attractiveness. The results also show that for attractive/ unattractive, female observers were more sensitive than the male in rating the images varying only in chroma; however, for images varying only in hue, male observers tended to be more sensitive than female. For masculine/ feminine, male observers tended to rate higher than female for all images. In terms of cooperative/ uncooperative, female observers tended to regard face images with higher-chroma values as less cooperative, while the opposite trend was found in the male response.

# Sublime ugly architecture

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## Abstract

Inside the 'Colour and Light in Architecture' research Unit of the Iuav University of Venice there is a group of researchers involved in the investigation of the colour and light role into the aesthetic evolution of the Italian architecture, specifically the one of the northern most industrialized area. The objectives and scope of the research is to identify the main phenomena that take place in the contemporary urban environment in order to find where colors and lights of the contemporary architecture are going. The method used to catch the first results is focused on analysis of the most evident urban phenomena, like as new colors and lights appearing on building façades, public interiors, furnishing and people clothing. Some initial results are pointed into the paper.

In places with high anthropic impact it seems that the ugly tends to prevail, generously sponsored by the market that takes to raise, and then sell its products. The chromatic dissonant, vulgar, ambiguous, are commonplace in every western city, none excluded. It seems that in these places the rules of color composition are to be rewritten, if these have never been. Also the urban building walls are more subject of attention from the street art, graffiti writers, stickers, stencil artists and so on. Their not institutional presence often entails overlapping of several layers run by different hands. It follows a mixture of colors, and messages, messy and contradictory, the same found in clothing of young generations, but also furniture and furnishings in the matching of many homes of common people. The lights and the colors of contemporariness sublimate in chaos, confusion, in self-contradiction of our time, where the architecture remains queen, not only by his shapes, but also in the chromatic exaggeration.

The coming of globalization and its consolidation has condensed the fragmentation that existed before its mass acceptance. What was not considered artistic in a place now became accepted hypothetically for the entire globe, opening more uncertainty and confusion channels never seen before. The local continue its daily scroll alongside some global aspects, variously locally amalgamated by changing not only the lifestyles and thinking, but also the interpretations. If each art should be able to represent its contemporariness, the complexity of today's world can only request a complex art. The complexity has moved inexorably in architecture, especially from a technological point of view. Here the architecture technologies act figuratively than in other arts, and then in the shapes, colors and lights that let perception, interpretation and signification. The continuous variation, change, modification, adaptation, shifting, combination or rejection, simultaneously establish the advent of new rules, if so we can say. Color and light, focal points of each speech concerning Visual Arts, including architecture, are emblematic of this change, ugly oriented, but in many cases contemporarily sublime.
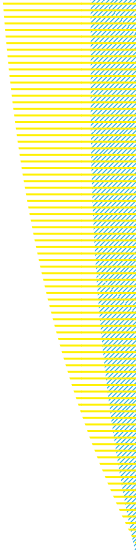
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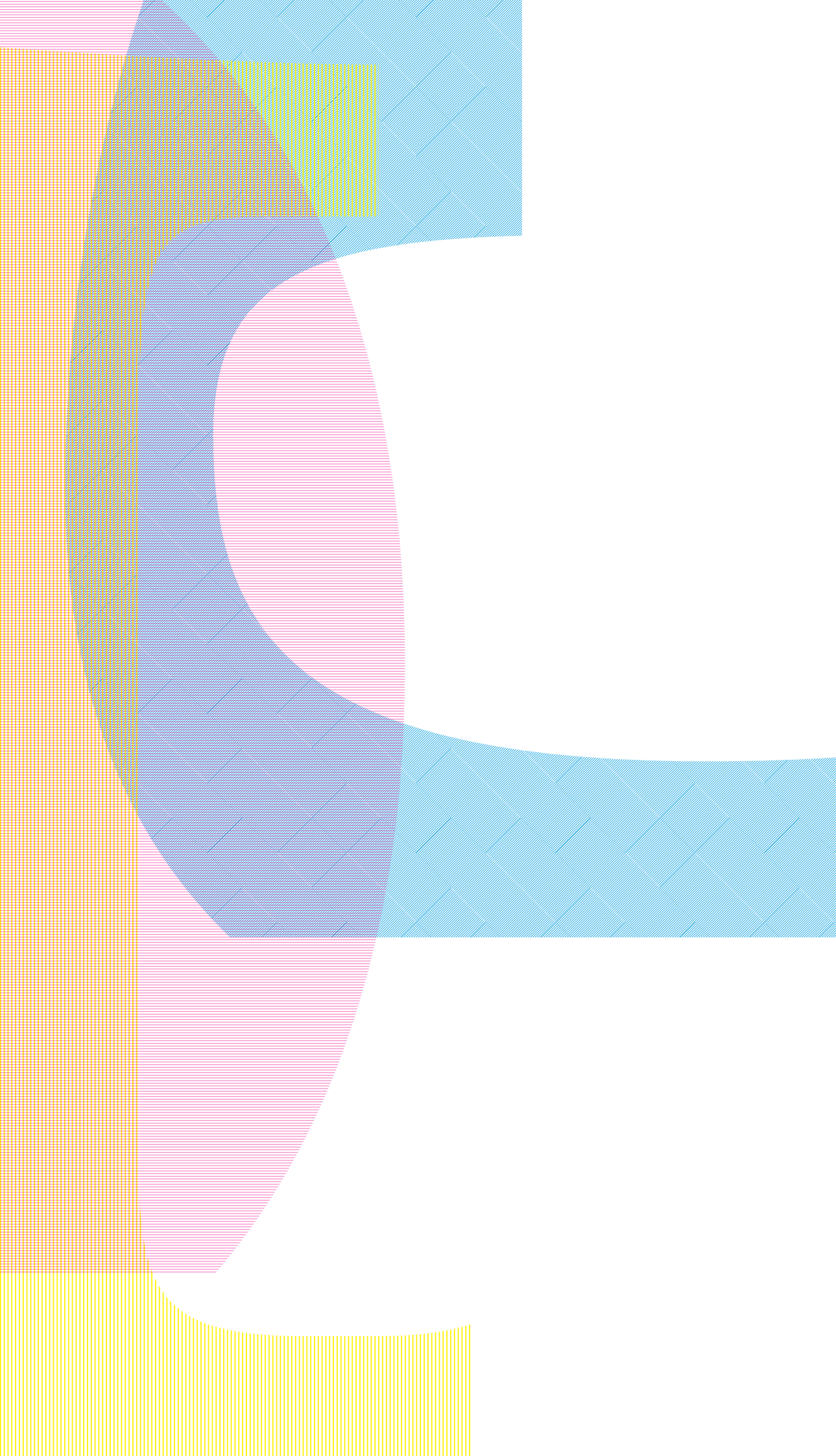
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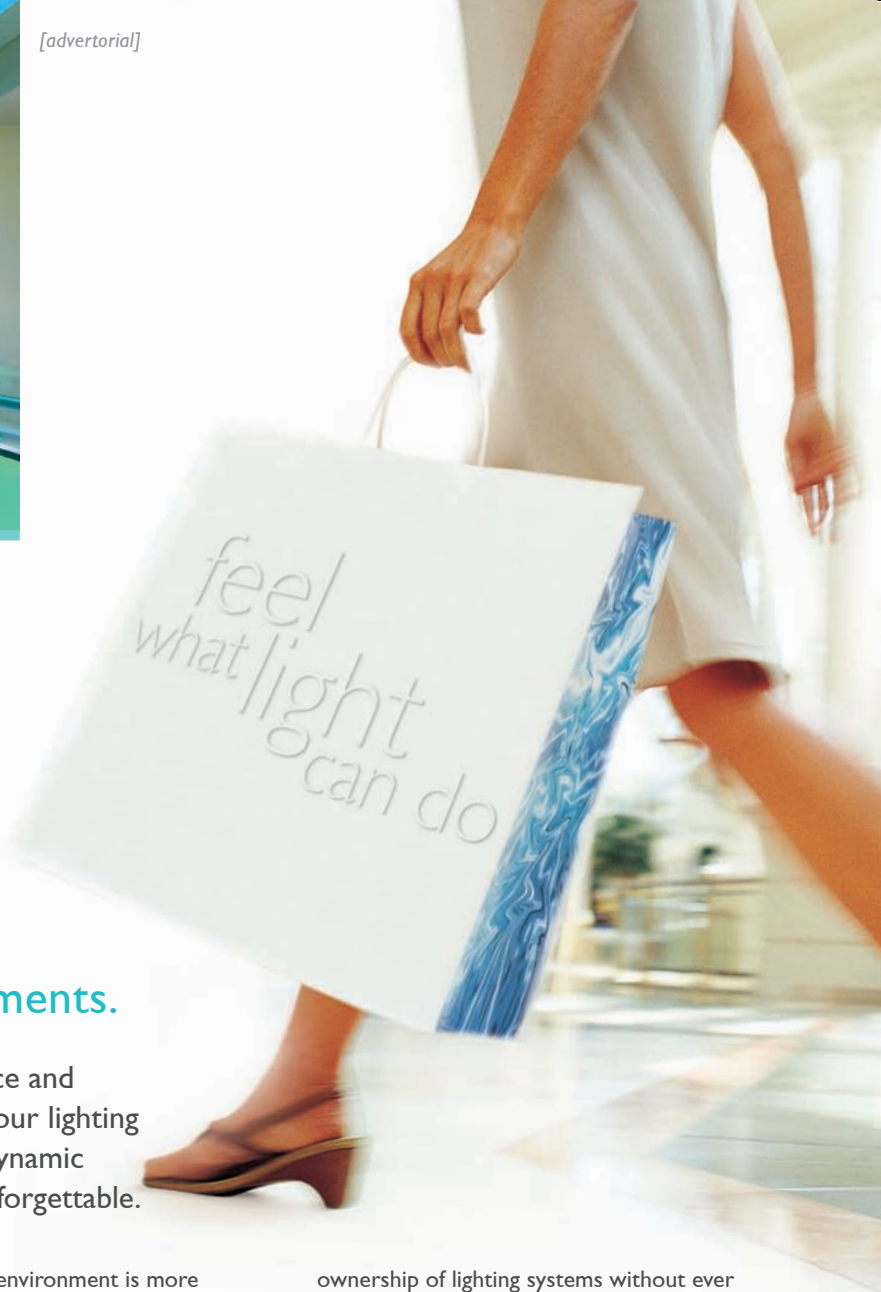
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