



# Book of Abstracts of the International Colour Association (AIC) Conference 2020

Avignon, France  
20, 26-28<sup>th</sup> november 2020

Sponsored by le Centre Français de la Couleur (CFC)  
Published by International Colour Association (AIC)

This publication includes abstracts of the keynote, oral and poster papers presented in the International Colour Association (AIC) Conference 2020. The theme of the conference was Natural Colours - Digital Colours. The conference, organised by the Centre Français de la Couleur (CFC), was held in Avignon, France on 20, 26-28<sup>th</sup> November 2020. That conference, for the first time, was managed online and onsite due to the sanitary conditions provided by the COVID-19 pandemic.

More information in: [www.aic2020.org](http://www.aic2020.org).

© 2020 International Colour Association (AIC) International Colour Association Incorporated  
PO Box 764  
Newtown NSW 2042  
Australia  
[www.aic-colour.org](http://www.aic-colour.org)  
All rights reserved.

#### **DISCLAIMER**

Matters of copyright for all images and text associated with the papers within the Proceedings of the International Colour Association (AIC) 2020 and Book of Abstracts are the responsibility of the authors. The AIC does not accept responsibility for any liabilities arising from the publication of any of the submissions.

#### **COPYRIGHT**

Reproduction of this document or parts thereof by any means whatsoever is prohibited without the written permission of the International Colour Association (AIC).

All copies of the individual articles remain the intellectual property of the individual authors and/or their affiliated institutions.

Graphic design | Stéphanie Cormier | Le Studio d'exées | [lestudiodexees.fr](http://lestudiodexees.fr)

# Table of contents

<b>ORAL PRESENTATIONS</b>	<b>4</b>
<b>COLOUR, ENVIRONMENT AND SUSTAINABILITY</b>	<b>5</b>
<b>SESSION 1</b> Materials and applications Sciences and industries: structural colours, natural colorants, bio-inspired pigments (food, cosmetics, paints, textiles...)	
<b>SESSION 2</b> Sustainability, health, biodiversity, lifespace, landscape, urban planning, building materials, etc.	
<b>COLOUR AND HERITAGE</b>	<b>22</b>
<b>SESSION 3</b> Material approach: past and future architecture, natural lighting, material and digital restoration, art materials, 3D digitization technologies...	
<b>SESSION 4</b> Cultural approach intangible heritage and knowhow, language, anthropology, teaching colour...	
<b>PERCEPTION, CAPTATION AND COLOUR CREATION</b>	<b>43</b>
<b>SESSION 5</b> Scientific Dimension and economical impact Human, animal and machine Vision ; economic impacts ; design, marketing, packaging...	
<b>SESSION 6</b> Social and cultural extents, New kind of knowledge and cultural dissemination (sound and light show, digital devices and human interaction), artwork reproduction, new fields of creation and digital colour fidelity to natural colours, ethics and virtual or real artwork restoration, virtual/real make-up, etc.	
<b>DIGITAL COLOUR AND VIRTUAL WORLD</b>	<b>59</b>
<b>SESSION 7</b> Technology, Colorimetry and instrumentation, spectral image synthesis, display devices (TV, video, mobilephone, overhead projector, Head Mounted Display, etc.), 2D and 3D digital printing, lighting, physics of colour, etc.	
<b>SESSION 8</b> Interaction between natural colours and digital colours, applications. Virtual Reality, Augmented Reality, Diminished Reality, image analysis, image synthesis, graphics creation and applications (movie industry, video games, medicine, odontology, prothesis fabrication, building and construction, etc.)	
<b>POSTERS SESSIONS</b>	<b>80</b>

# ORAL PRESENTATIONS

## SESSION 1

005 | 056 | 089 | 094 | 106 | 109 | 147 | 148

## SESSION 2

006 | 024 | 025 | 077 | 078 | 096 | 131 | 135

## SESSION 3

011 | 013 | 019 | 023 | 047 | 052 | 092 | 143 | 145 | 146

## SESSION 4

020 | 028 | 032 | 034 | 041 | 044 | 055 | 057 | 073 | 084

## SESSION 5

016 | 022 | 029 | 035 | 039 | 048 | 068 | 095 | 101 | 114

## SESSION 6

051 | 066 | 080 | 105 | 130

## SESSION 7

001 | 026 | 061 | 083 | 086 | 108 | 113 | 115 | 116 | 118 | 136

## SESSION 8

040 | 046 | 053 | 054 | 059 | 111 | 119 | 121 | 124

## SESSIONS 1 & 2

# COLOUR, ENVIRONMENT AND SUSTAINABILITY

### SESSION 1

**Materials and applications Sciences and industries:  
structural colours, natural colorants, bio-inspired pigments  
(food, cosmetics, paints, textiles...)**

Part 1 005 056 089 094

Part 2 106 109 147 148

### SESSION 2

**Sustainability, health, biodiversity, lifespace, landscape,  
urban planning, building materials, etc.**

Part 1 006 024 025 077

Part 2 078 096 131 135

## From the design to the sale of make-up product shades: contribution of the expertise of colourists in research and development

Hélène de Clermont-Gallerande\*

CHANEL Parfum Beauté, Innovation & Development Make-Up Formulae, Pantin, France  
\*Corresponding author: helene.declermontgallerande@chanel.com

At CHANEL, colour is both a heritage and a source of innovation that allows to offer approximately 350 new shades every year. This colour heritage includes the five colours that Gabrielle Chanel liked to surround herself with: red, black, white, beige and gold. The designer who creates a seasonal make-up collection takes into account their own inspiration, their vision of current trends... They also need to consider the needs of the customers, and how to juxtapose new seasonal shades in an existing product range, while avoiding duplication.

The shades are chosen one and a half to two years before the collection is launched. The inspiration is then translated into a «brief», i.e. into «words» and material samples. This must be accurate so that the scientists can transpose the colours as faithfully as possible.

The colourists' work begins 15 months before the launch. Tone, undertone, opacity, brightness, reflection... Each colour developed is studied in its colorimetric composition to meet the target. The proportions of each pigment needed to achieve the shade are determined and the behaviour of the pigment when diluted is anticipated. Regulatory constraints are respected: the chemical nature of the pigments contained in the formula depends on where on the face the product is applied. All references are validated no later than 12 months before launch. A spectroradiometric measurement is carried out to establish the industrial specifications for the manufacturing phase, which can take place several months after the colour has been validated.

The pilot phase focuses on the impact of the manufacturing equipment and of the increase in the quantity manufactured on the colour. Dispersion of pigments is optimised as the procedure is developed. The shade is compared with that of the laboratory to verify the homogeneity. A file including the rules for correction is sent to the industrial teams so they can adjust the formula to absorb the inevitable colorimetric variability of the pigments and pearlescent materials.

The quality laboratory compares the batch of pigments received with a benchmark and with previous batches in order to detect any deviation in colour. Pigment grinding, which enables optimum dispersion, undergoes similar controls. The spectroradiometric measurements on pigments and the grinding processes make it possible to determine a usability factor called colour strength and to adjust the pigment formula transmitted to the manufacturing plants. Visual and instrumental methods are used to establish the conformity of a finished product to a benchmark.

Marketing orchestrates the launch of new products. It defines strategy and sales forecasts. Architectural design is used to showcase the colour at the point of sale. The tilt at which tester products are displayed and the lighting are designed to allow customers to see the shades and view the range in the best possible conditions. The colour is reproduced in printed or digital form so it can be presented and promoted. The colours wanted by the designer must appear on all forms of advertising.

During the whole process, the colourists will check and validate the colours reproductibility: they have essential and rare skills.

### KEYWORDS

make-up | colourists | research & development | design | cosmetics

## Natural dyes and naturality: How to prevent from falsifications - special case of indigo.

Patrick Brenac<sup>a\*</sup>, Isabelle Castel Brenac<sup>a</sup>

<sup>a</sup>Green'Ing Sarl, Hameau des Douze, 34600 Bédarieux, France  
<sup>\*</sup>Corresponding author: patrick.brenac@green-ingredients.com

The interest and renewal of natural dyes has been growing in the last decades. The increase of productions, of demands, the developments for larger markets with more economical regards, did contribute to falsifications by blending or replacing some natural dyes by synthetic - and cheaper - ones.

Numerous cases of falsification suspicions are observed for several years, altering the image and positive impacts of natural dyes for people and nature. Users of natural dyes (private, craftsmen or professional dyers), retailers, industrial brands, final customers: Many of us may be deceived.

Indigo is, by far, the most falsified (but not the only one). This question and concern were raised in previous international conferences in the last five years, did initiate exchanges and motivated research.

Our company has tried to be highly involved in these efforts and to encourage all research to struggle against falsifications.

This presentation will provide information and examples of analytical methods used for the evaluation and quality of indigos, sometimes in combination. In the last years, we have analyzed indigos from several botanical and geographical origins, collected observations and data that did contribute to raise doubts of naturality for some of them, but could not constitute formal proofs. In the last months we did successfully experiment a technique that can now be used to prove the naturality and determine the percentage of indigo from natural or synthetic origin - and by extension of other compounds. This method of quantification of the biobased content relies on the determination of <sup>14</sup>C over the total carbon of the compound (since the <sup>14</sup>C isotope is present in recent plants and animals and absent in petrochemical compounds).

We hope that this research will contribute to the reduction of false natural indigos (and other natural dyes) on markets and will encourage the manufacturers to stop such practices. Beyond the technical aspects, proving the percentage of natural compounds will open new ways for the quality and marketing of natural colors, for all people involved in their production and transformation over the World and for all of us, final customers.

### KEYWORDS

natural dye | indigo | analysis | adulteration | naturality

## **BioColour – Bio-based colourants for sustainable material markets: a fungal-based anthraquinone for PLA and PET in supercritical carbon dioxide (SC-CO<sub>2</sub>) dyeing**

Riikka Räisänen<sup>a\*</sup>, Gerardo A. Montero<sup>b</sup>  
Harold S. Freeman<sup>c</sup>

<sup>a</sup>University of Helsinki, Helsinki, Finland

<sup>b</sup>Green Consultant, Raleigh, NC, USA

<sup>c</sup>North Carolina State University, Raleigh, NC, USA

\*Corresponding author: Riikka.raisanen@helsinki.fi

Bio-based materials and new dyeing technologies have gained growing interest in different applications, as companies actively want to enhance products sustainability and remove environmental and hazardous pollutants during the manufacturing process. Degradable and recyclable textile and package innovations are increasing. However, currently synthetic colourants are used, and synthetic dyes and pigments are designed to be stable, which poses problems with bio-degradability. The challenge set by the sustainable society was a key motivation for a project recently funded by the Strategic Research Council at the Academy of Finland, 2019–2025. Specifically, the BioColour project is designed to advance the usage of environmentally sound colourants from fungal and plant sources in different applications. Our project aims to initiate an expansion of current coloration principles and consumer preferences to include an emphasis on sustainability in businesses and consumer lifestyles. This includes developing new methods of biocolourants' large scale production, characterization and applications. Important is the gained fundamental understanding of biocolourants, and also the societal acceptance of consumers needed for successful implementation.

When targeting improved colouration of materials, focus can be laid on colourants, substrates and methods. All of these are under investigation in the different work packages and tasks of the BioColour project. In this paper we will focus on studies pertaining to waterless dyeing studies using supercritical carbon dioxide (SC-CO<sub>2</sub>) and a natural dye for polylactide (PLA) and polyester (PET) fabric coloration.

Materials and methods. PLA pellets were drawn into 15  $\mu$  multi-filaments from which single knitted fabric (114 g/m<sup>2</sup>) was produced. Polyester was commercial interlock knitted fabric (133 g/m<sup>2</sup>). Fungal anthraquinone, emodin, was used as a natural dye (1% on the weight of the fibre) for PLA and PET fabrics in SC-CO<sub>2</sub> dyeing using total dyeing times of 1h and 1h 25 min, respectively. The colour of the dyed materials was measured as CIELab values, and the K/S (max, abs) was reported. Colour fastness to rubbing was studied according to the ISO 105-X12:2016 standard.

Results. The results show that the small size and hydrophobic nature of the anthraquinone dye resulted in a uniform dyeing on PLA and PET fabrics when SC-CO<sub>2</sub> was used as the dyeing medium. The dyed fabrics had excellent rubbing fastness which together with the microscopic evaluation revealed that the dye had penetrated into the fiber structure completely. These results, together with our previous work from dyeing at 120–130°C in aqueous media, show that anthraquinone-based biocolourants possess the required thermal stability, produce bright colours and give uniform dyeing result on PLA and PET fibres.

Conclusions. Increased usage of biodegradable and recycled materials in textiles would benefit from biocolourants which are stable under end-use conditions, produce bright colours and have acceptable tinctorial strength. Anthraquinones are well known as colourants historically and this study indicates that they are suitable for dyeing in the SC-CO<sub>2</sub> waterless medium. It now remains for us to broadly assess their toxicological properties and select the most promising ones, i.e. those of non-toxicity as well as good stability and colourfastness, for commercial-scale dye application studies.

### KEYWORDS

biocolourant | anthraquinone | supercritical carbon dioxide dyeing | polylactide PLA | polyester PET



## Gonio-photometric spectrum analysis and texture evaluation of structural color design – Considerations on “Peacock feather weave” by Kondaya Genbey

Yumi Awano<sup>a</sup>, Masayuki Osumi<sup>b</sup>

<sup>a</sup>Tokyo Zokei University, Tokyo, Japan

<sup>b</sup>Office Color Science Co., Ltd., Yokohama, Japan

\*Corresponding author: awano@zokei.ac.jp

We can find many expression those using motifs a natural structural colour since ancient times around the world. It evidences the common recognition that the appearance of the structural colour as “beautiful”. We have pointed out on the past study that the element of «ethereal» had a significant effect on the sensitivity of “beautiful” for materials change the shape, gloss and shading in time and space.

In this article, we focused on the appearance of the structural colour of peacock feathers, measured optical characteristics with a gonio-photometric spectrum imaging system (spectral reflectance measurement every 10 nm from 420 to 700 nm under three angles of illumination of 15°, 45°, 75°) on below samples. Then collated it with microstructure observation with a microscope, and besides the texture impression evaluation.

A. Natural peacock feather B. Horizontally arranged fluffy plume pieces

B'. Horizontally arranged pieces of the top of the eye-shaped pattern

C. Partially peacock feather obi (kimono sash belt) for a female weaving the B' into the weft

Sample C design is adapted with a technique of the lore of the all peacock feather Jinbaori manufactured during the Azuchi-Momoyama period (1573-1603) that reinterpreted by Kondaya Genbey. Jinbaori is sleeveless campaign jacket what warlords wear over armour for protection from weather and demonstrate its status or power to allies and enemies. Some warlords appeared a dauntless attitude with foppish at the period of the warring states. In the case when the all peacock feather obi (finest product of C) is wrapped around a human body in a traditional way of dressing, the weft is vertical on the abdominal side and horizontal on the «taiko» (drum knot on the backside). Interestingly, the two different spectral characteristics change depending on human behaviour. In virtue of weaving the fluffy plume at the top of the eye-shaped pattern (as sample B') into the weft, colour and lustre appear changing on a soft surface like a carpet generates an illusion of warm and smooth tactile. It shows an artificially refined the wonder of natural structural colours as «ethereal beauty» that is different from natural peacock as an animal.

The mechanism of peacock feathers structural colour has been known that regularly arranged melanin granules in the cortex on the surface of feathers causing light interference in the visible light region. On sample B, it was confirmed that when the geometric condition of the illumination changed from 15 ° to 75 ° in the vertical direction, hue change from reddish to greenish. Hue changes with extremely high response to geometric conditions in the zenith angle direction and was little dependence on the azimuth angle direction. From these results, it was confirmed that the spherical granules were regularly arranged and the size of the particles just acted as interference in the visible light region, which matched the reason for the appearance of the structural colour. Though sample B' appears a similar response with sample B on spectral characteristics, according to its density and section roundness of barbule, it could be considered that appear more pronounced trend. Since the colour gamut varies depend on the results of interference according to the different distance melanin granules in the part of the cortex, we continue to more detailed observations with a scanning electron microscope to the actual undulations and pitches of the particles will carry out.

## Organic Paint: Anthocyanins at the Service of Contemporary Artist

Zoriana Lotut

University of Warsaw, Warsaw, Poland  
zoriana.lotut@student.uw.edu.pl

Anthocyanins are organic pigments that are found in the leaves, petals, and fruits of a variety of plants. Together with carotenoids and flavonoids, the anthocyanins constitute the 'palette' of flora, and their function is to attract pollinators, protect the plants from ultraviolet light and repel predators using their bitter taste or toxicity. Through organic pigments, plants create various chromatic effects that aid their survival and are helpful for either distinguishing between ripe fruits or admiring the changing colour of foliage in autumn. Nowadays, anthocyanins are widely used as a food colourant and are known under the code E163. They are non-toxic and have antioxidant properties.

Previously, anthocyanins were used as paint; they have been mentioned in numerous historic colour recipes as a source of purple dyes or inks. However, this fragile, organic colourant could not withstand the rivalry of the constantly evolving and improving dyes and pigments. Anthocyanins were ousted from the domain of arts and textile dyeing because they could not provide sufficient colour stability, which is one of the most sought-after qualities in colours. On the contrary, nowadays, due to the growing concerns about the environmental threats from the extensive use of synthetic dyes, many are looking for alternative organic and environmentally friendly colours, even if they are impermanent.

This project revisits the use of anthocyanins as an artistic paint. It will use the red cabbage (*Brassica oleracea*) as a source of anthocyanin. Being natural indicators, i.e. substances that are sensitive to pH changes, anthocyanins can produce a variety of hues that range from red/pink/orange to purple/blue/green. This inherent capacity of chromatic metamorphosis is the focus of the given artistic project. By manipulating the acidity and alkalinity, the full range of the 'palette' of the anthocyanins will be highlighted in a variety of artworks. The aim is to question the long-existing obsession with the durability of colour by using one of the least colourfast paints, to promote the artistic value of chromatic mutability and to support the potential of the impermanent organic colour material in contemporary art. References to several artists who focus on plant-based material (Wolfgang Laib, Giuseppe Penone and José Maria Sicilia) and chromatic mutability (selected paintings by Andy Warhol) will be provided.

### KEYWORDS

colour materiality | plant-based paints | anthocyanins | pH | contemporary painting

## The influence of colour mixtures on the textural perception of surface design: deciphering textile methodology in the field of bio-plastic design

Delia Dumitrescu, Marjan Kooroshnia\*,  
Jessica Carolina Cornelia Rijkers

The Swedish school of textiles, University of Borås, Sweden  
\*Corresponding author: marjan.kooroshnia@hb.se

In textile design, the textural characteristics of a surface are built on the properties of the materials, the textile technique/s used, and the colour mixtures associated with each technique. The perception of colour on textural textiles is dependent on the angle when viewing and the angle of incident light on the surface. Accordingly, when analysing the perception of colour in pile textiles such as velvet, we observe that the orientation of the piles on the surface affects the appearance of colour. The perception of colour and its transformation depends on whether the light is reflected off the side or the end of the yarn; this can be described as seeing the colour of pile textiles appear lighter or darker depending on their orientation within a space.

By bringing DIY materials, i.e. bio-plastics, into the textile design field, we question how this hybrid material territory can be further developed using textile surface design methodology, and how the relationship between texture and colours can be advanced in the design of complex textured surfaces. Accordingly, this research addresses two questions: i. how the character of bio-plastic material impacts the potential colour design and selection, and ii. how the visual perception of a coloured bio-plastic surface changes according to differences in texture, the position of a light source, and angle of view.

The experimental work focuses on the creation of textures through the use of laser cutting technology and the formation of complex colour mixtures. Diverse methods of colour mixing were explored to create double-sided coloured surfaces. Different recipes for making flexible, transparent and opaque, bioplastic surfaces were tested. Laser cutting was used as a method to create visual colour mixtures rather than through the direct mixing of media such as paint or dye. In this context, laser cutting technology allowed the formation of layers and shapes as a method to visually mix unique colours within the surface texture. The result of this visual mixing of colours occurs in the form of texture similar to the pointillism technique. Using this method, basic geometric design elements, e.g. dots, lines, and shapes, are positioned close to one another and placed on the dual-coloured bio-plastic surfaces, so that the colours are perceived as an overall tone; similar to the effects that can be created by yarn blending in textile construction techniques such as weaving and knitting.

The result builds on a qualitative assessment and proposes, as an outcome of the experimental research, a series of design methods which indicate how value or/and saturation of the coloured textural bio plastic is dependent on the orientation of cuts made on the surfaces, the light source direction, and angle of view. As bio-plastics are fairly new materials for the field of textiles, we aim to illustrate the design possibilities that can be achieved when a new category of sustainable materials and textile methodologies of designing color and texture intersect. This new material category could also offer a more sustainable alternative to conventional textile materials for interior design.

### KEYWORDS

*bio-plastics | colour mixtures | textile methods | sustainability*

## Relationships between natural color, mineralogy, and decay of the ashlar of the Palace of the Popes (Avignon, France)

Jeremie Berthonneau<sup>a\*</sup>, Paola Scaramuzza<sup>b</sup>,  
Philippe Bromblet<sup>a</sup>

<sup>a</sup>Centre Interdisciplinaire de Conservation et Restauration du Patrimoine,  
21 rue Guibal, 13 003 Marseille, France

<sup>b</sup>Faccio Engineering S.R.L., Via Astichello 18, 35 133 Padova, Italy

\*Corresponding author: jeremie.berthonneau01@gmail.com

The architectural technique of alternating ashlar of light and dark colors originates from the Byzantine empire and has spread across the Mediterranean basin during the middle ages through Islamic, Romanesque and Gothic architecture. The Palace of the Popes (Avignon, France), witness of the cultural exchanges of the 14<sup>th</sup> century, exhibits yellow ashlar on its façades and alternating yellow and grey ashlar on the tower quoining, bays, and vaults. The two types of ashlar were quarried from the same geological formation of bioclastic limestones, called “Pierre du Midi”, outcropping at various locations near Avignon. However, the grey type systematically displays a significant loss of plates on the stone surfaces. The intensity of this decay pattern, called spalling, spans from aesthetic disorder preventing the reading of the alternation of colors, to actual threat to the structure stability. The superficial repair or replacement of the grey ashlar are therefore part of the scientific questions of the ongoing restoration campaign at the Palace. As the natural color of geological materials is intimately related to the mineralogical composition, we designed an experimental study to establish the mechanistic relationships between these internal properties and the sensitivity to spalling. The color of the two types of ashlar was first evaluated by measuring the lightness and chromaticity (CIE L\*a\*b\* color space) with spectrophotometry. The mineralogical composition was then fully characterized with a focus on the clay mineral content. A semi-quantification of the clay mineral species, especially those displaying swelling properties, was performed by a combination of X-ray diffraction and energy-dispersive X-ray spectroscopy. These quantities were then compared with the results of methylene blue adsorption tests. In the meantime, the mechanical behavior of these stones was followed along water content variation. We first recorded the dynamic deformation corresponding to hydric dilation and then the evolution of tensile and compressive mechanical strengths. Our results highlight that the sensitivity to spalling of the ashlar is explained by their contrasting hydric dilation and mechanical softening. An interesting relationship between natural color, swelling clay minerals content, and hydric dilation was also evidenced and corroborated the spalling sensitivity. We therefore extended our study to the colorimetric, mineralogical, and hygro-mechanical properties of a large ensemble of “Pierre du Midi” samples quarried in the Provence region, as well as sedimentary stones from Switzerland and Italy. We thus compared the natural color and expected spalling sensitivity of these stones to identify the best candidates for the replacement of the grey ashlar, i.e. those displaying comparable natural colors and mechanical properties but with a lower sensitivity to spalling. Collectively, our results further the understanding of the relationships between natural color, mineralogy, and sensitivity to decay of building materials and provide useful insights on restoration strategy.

### KEYWORDS

building material | natural color | spalling | clay minerals | dilation kinetic

## The renewal of natural dyes from plants

Christine Brunet, Anne de la Sayette

ARRDHOR CRITT Horticole, Rochefort, France  
c.brunet@critt-horticole.com

CRITT Horticole has carried out a unique and multidisciplinary research program, for 25 years, focusing on the revival of the natural dyes from plant. Bibliographic, botanical, agronomic and biochemical research stages were necessary to select the varieties cultivated today in France. Partnerships with producers around the world have also been established for the supply of tropical plant species.

Natural dye plants cover a wide range of colors whose perception is different from synthetic colors. Thanks to its know-how, CRITT has thus developed soluble coloring extracts for textile dyeing, hair coloring, but also pigments for cosmetics, painting and recently the coloring of bio-based plastics.

Today, the demand is strong in all industrial sectors, driven by concerns for environmental protection and the search for qualified and traceable products. Plant dyes and pigments are added up to the list of renewable natural ingredients, produced with green processes.

### KEYWORDS

natural dyes | renewable | green process

## Polychrome or monochrome? An interpretation of morphological approach to urban colour in a Chinese context

Jie Xu<sup>a</sup>\*

<sup>a</sup>Loughborough University, School of Design and Creative Arts, UK  
\*Corresponding author: j.xu3@lboro.ac.uk

This article reviews a theoretical framework (Song, 2018) and the related concepts that explore an approach to urban colour. The aim of this research was to understand the complexity of urban colourscape and relation between urban spaces and colour in urban development. Drawing on a range of theories and studies from etymology, urban morphology, colour epistemology, the model of 'urban colour' response to building attributes provided a theoretical framework which to examine urban colour.

In particular, the framework provides four key concepts: urban landscape, marketplace, monochrome, and polychrome, which facilitates the understanding of Chinese urban form and guiding contemporary development in respect of traditional spatial qualities and colour relations. Consequently, the study examines the fourth criteria to urban colour including: colour theme for city, colour theme for marketplace, colour pattern for city, and colour pattern for marketplace, that suggests distinctive approaches to urban colour within the context of urban design and planning.

Based on the basic recognition of epistemology as an inquiry for methodology, the research brought the discussion into 'zoning design' and 'toning design', which further explored a new area and related process in urban colour design and planning. The colour plan and design thus are based on the principle of urban morphology that studies the characteristics of the place and the relationship between place and place. This should often be in the primary stage throughout the design process.

The study observes that an emerging revival of traditional wisdom has been implemented in China's contemporary urban design practice. As a complex synthesis in any culture, urban colour plan is a product of local social, economy, political relationships. It finds out that the urban design and planning should be encouraged the local knowledge and intellectual to involved in the design revolution.

### KEYWORDS

*urban colour | urban colourscape | urban morphology | urban colour design and planning*

## Tactical Urbanism: Colour interventions with purpose

Zena O'Connor, PhD

Design Research Associates, Sydney, Australia  
Corresponding author: zena@zenaoconnor.com.au

Evidence-based interventions in the urban landscape are becoming more common in many countries and have garnered the term 'tactical urbanism'. In this context, tactical urbanism can be defined as relatively low-cost changes to the built environment intended to improve local neighborhoods and urban spaces. While guerilla variations of tactical urbanism exist, this paper will focus on planned and deliberate changes aimed at providing solutions for urban environment challenges.

Deliberate and planned colour interventions intended for café precincts, plazas, traffic/pedestrian shared zones, pedestrian/cyclist shared zones, pedestrian crossings, and urban 'blank canvas' sites, are aimed at achieving specific goals beyond aesthetics and surface decoration. In the urban landscape, colour interventions can be specifically designed to achieve the following purposes:

- 1) Revitalise and activate urban areas and encourage engagement;
- 2) Support orientation and wayfinding strategies by visually defining precincts, pedestrian/shared zones and key urban landmarks;
- 3) Improve environmental visual literacy for people with declining visual and cognitive capacity;
- 4) Enhance safety by highlighting key design intervention features;
- 5) Support cultural diversity by incorporating culturally-based colour and design motifs;
- 6) Provide visual links to local cultural events.

This paper aims to postulate an evidence-based rationale that will underpin submissions to local councils in Sydney in respect to colour interventions with purpose. This rationale will include references to recent successful urban colour interventions plus the outcomes of research conducted by the author. A survey approach was used to identify a range of recent colour interventions that have attracted positive community feedback and which have achieved one or more intended goals, as detailed above. In addition, the outcomes from recent research which investigated the effectiveness of colour/contrast designs within the context of pedestrian crossing design are included (O'Connor, 2019 & 2018). In conclusion, the long-term aim is to garner approval for targeted colour interventions with purpose that are site-specific in Sydney based on survey outcomes and recent research.

### KEYWORDS

tactical urbanism | colour intervention | colour design | urban design | urban colour

## Legendary pigments: Bridging the gap between natural world and the digital world

Zena O'Connor<sup>a\*</sup>

<sup>a</sup>Design Research Associates

\*Corresponding author: zena@zenaoconnor.com.au

Coloured pigments are a relatively abundant resource in the twenty-first century and we now enjoy access to a huge range of pigments, the vast majority of which are synthetic. In addition, colour across digital applications allows us to explore and apply an equally large range of coloured hues, albeit in digital format.

However, this abundant range of pigments was not always the case. From the emergence of the earliest pigments and dyes in the pre-history period through to the Middle Ages and the Renaissance, access to pigments and dyes was restricted to a very limited range due to a number of constraints including geographic accessibility, limited trade as well as cost considerations. It wasn't until the changes wrought by the Industrial Revolution from mid-eighteenth century through to the mid-nineteenth century that the ever-increasing development and manufacture of pigments and dyes began to occur.

Despite the current widespread accessibility of pigments, specific dyes and pigments have achieved legendary status among historians, designers and artists alike. Over time, these pigments have become highly familiar due to their celebrated status and their ubiquitous appearance in eminent and highly-recognized paintings and applied design. While the hue, tonal value and chroma may not always remain stable, synthetic variations of these legendary pigments are now widely available.

This paper aims to identify and describe coloured pigments and dyes that have achieved legendary status. Advances in digital technology have provided the means to visually identify these legendary pigments and dyes using a relatively high level of specificity. In doing so, this paper aims to document pigments and dyes, and transfer their application to the digital world before they have vanished or become defunct. The outcomes from this paper will enable digital artists and designers to use and apply legendary pigment colours using digital technology. In addition, curators, researchers and historians will have the information required to faithfully replicate legendary pigments across a range of digitally-based applications.

### KEYWORDS

*legendary pigments | pigments and dyes | natural colours | digital colours*



## Slip and pigment layers of pre-Columbian ceramics of Guanacaste and Central Valley of Costa Rica

Matthieu Ménager<sup>ab\*</sup>, Patricia Fernández Esquivel<sup>b</sup>,  
Paula Sibaja<sup>c</sup>

<sup>a</sup>IMBE- Avignon University/ CNRS/ IRD/ Aix-Marseille University, Restoration Engineering of Natural and Cultural Heritage, Faculty of Sciences, Avignon, France.

<sup>b</sup>Centro de Investigaciones Antropológicas, Universidad de Costa Rica.

<sup>c</sup>Escuela de Química, Universidad de Costa Rica.

\*Corresponding author: mat.menager@gmail.com

The pre-Columbian cultures of Costa Rica had great knowledge of the techniques of manufacture of ceramic objects. Most of artefacts present decorations, patterns and colours elaborated with natural pigments. Many types of ceramics from Guanacaste, (Jicote, Mora, Chircot, Altiplano, Birmania) were traded to others regions in Mesoamerica. The raw material of pigments were geomaterials (generally clays or metal oxides) from natural sites formerly chosen on empirical criteria for their optical and mechanical properties. The aims of this work were to identify the raw and archaeological materials and techniques used to produce ceramics, and to produce the first pigment study in this archaeological zone.

Firstly, we sampled and characterized 91 coloured Costa-Rican geomaterials by portable X-Ray Fluorescence, infrared and Raman spectroscopy to build a database of raw material in order to maximize the interpretation of analytical data. For the techniques of crafting, an ethnographic study of the potters from the indigenous community of Guaitil (Guanacaste, Costa Rica), which make ceramics using local materials and ancient techniques. This allowed us to observe the techniques currently used for the application of colours (slip and pigment layers).

In a second part, 139 archaeological ceramics, originally crafted in Guanacaste and Central Valley, were selected and sampled from various Costa-Rican sites localized in Guanacaste, Central and Caribbean regions. We used X-Ray Fluorescence, Scanning Electronic Microscopy, infrared and Raman spectrometry to analyse the red, black, grey and white pigments and slips applied on shreds. All these data were treated statistically (PCA, HCA, LDA) allowing to find specific chemical fingerprints and fabrication techniques according to the type of ceramic and the archaeological area. The colours of the slip and pigment layers were done using different clays, iron and manganese oxides. We also could observe the homogeneity of the coloured layers used for 2 important groups of Guanacaste ceramics, and the heterogeneity of composition for those of the central valley. Such result could be link to the social organizations in the two archaeological zones. The grey pigment of a type of ceramic from the central Valley was surprisingly make by mixing calcined bones, clay and iron oxides.

### KEYWORDS

pigments | ceramics | raw materia | sourcing | Costa Rica

## **Art with soil: Geotinta Project and its contribution to the teaching and using of colors in Design.**

Adriana Vital, Camila Silva

Federal University of Campina Grande, Campina Grande, Paraiba  
Corresponding author: [silva.camila.assis@gmail.com](mailto:silva.camila.assis@gmail.com)

The soil is a biodiverse natural resource and rich in colors and textures. Due to its ecosystem functions, it sustains life on Earth, but it is still unknown and little valued by the community in general, a fact that can aggravate misuse and degradation. Among the morphological characteristics of the soil, the color is the one that most stands out when the description study for soil classification is done. The soils can be presented in different colors, going from light to dark, indicating the presence of quartz, organic matter, iron. This richness of tones is due to the factors of soil formation, such as the type of rock, relief, climatic factors, as well as to the uses and management adopted.

This paper presents a work of art with soil that has been developed in northeastern Brazil. As well as, it presents the possibilities of interdisciplinarity with the field of design, with regard to teaching and the use of colors. Geotinta is a project of the Agroecology course at the Center for Sustainable Development in the Semiarid Region of the Federal University of Campina Grande. The course is taught at Sumé campus, located in Cariri Paraibano. The project arises from the opportunity to disseminate concepts about the potential of non-agricultural land use. The working environment is the Geotinta's Studio, located in the Soil Education Space on the university campus. The studio has a collection of colors made up of soil samples from different locations and cities. Using the Munsell Color chart, the team has already cataloged more than 40 shades of colors.

The use of soil colors as a raw material for the development of paints, in addition to the enhancement of the environmental resource, brings up important issues such as the feeling of identification and belonging of people with their environment. In addition to the scientific exercise of recognizing and cataloging colors from the soil, Geotinta covers symbolic aspects of color. The concept of identity and territory is evident from the Geotinta Project and, consequently, opportunities are opening for the field of design with regard to the use of color as an element for cultural identification. In this article, we will present the colors of the Paraiba soil and discuss how these colors contribute to the process of training the Brazilian designer.

## Natural colour as a resource for textile production chain in Italy

Rosellina Cilano<sup>a</sup>

<sup>a</sup>Associazione Colore e Tintura Naturale Maria Elda Salice

This paper presents the results of an activity - which I carried out in Italy within a research and training institute - focusing on the issue of introducing natural dying in Textile and Fashion Industry. The aim of the proposal is to consider the potential for introducing colorants extracted from tinctorial plants in medium-craft and /or industrial production as an alternative or a complementary solution to synthetic dyeing, rather than prospecting the substitution of synthetic colors with natural dyeing – an unrealistic hypothesis in the light of the complexity of the present textile and fashion productive system.

Recently the textile industry has been undergoing a reconversion of its productive processes aimed to create products having a lower environmental impact and taking into account new health consumers' needs. This has often required the identification of alternative materials and processes. It is within this innovative framework that textile industry has shown a growing interest in natural colorants.

**Sustainability:**As a matter of fact, natural colour may be actually considered as “more sustainable” under different aspects. It is strongly linked to natural environment and territory both physically (natural vegetation, agricultural products) and culturally (dyeing art craft, history of economic policies and costume). Its undoubtable strength point is its hybrid nature which enable contacts with different disciplines such as biology, chemistry, psychology, sociology etc...Nowadays natural colour is present in different productive sectors (food, cosmetics, art, architecture, textile and fashion).

**Resource:** Are therefore tinctorial plants and natural colorants an actual resource for present productive world? May they represent a resource, not only from scientific and theoretic research point of view, but in a productive approach in textile sector to be carried out on a large scale? In the last decade, Italy is witnessing the following trends.

**At craftwork level:** A multiplication of initiatives and attempts of development are inducing an optimistic perspective on the growing use of natural dyes in productive processes. The mapping of territorial presences linked to natural dye (cultivation and experimental production of tinctorial plants, small craft companies transforming raw materials into colorants, dyeing plants, laboratories of textile production, small tailoring companies for clothing) shows a situation characterized by micro-small craft companies quite fragmented on the territory, with some weak attempts of production chain.

**At the industrial level:** Companies are beginning to consider the possibility to introduce natural colorants to dye natural and organic fabrics linked to the re-use of farming waste and food manufacturing scraps. Within this framework, the idea is building a network including all the small productive entities and establishing a strong cooperation with training and research organizations, so to combine craft knowledge with new technologies and innovative communication strategies. Such an initiative may induce a key change giving birth to an innovative project where the dyeing practice is not just the reproduction of a traditional knowledge, but represents an incentive for product and process innovation in textile and fashion industry.

### KEYWORDS

sustainability | territory | natural color | dyeing | textile

## Color design research and developments with natural dyes

Delphine Talbot<sup>a\*</sup>

<sup>a</sup>Institute Color Image Design, University of Toulouse, France  
<sup>\*</sup>Corresponding author: delphine.talbot@univ-tlse2.fr

Young design researchers are currently working on new products using natural dyes. In addition, they are studying how colors made with plants can be used as effective materials. Sensory design and care design are innovative design methods that define and include new uses for humans.

The current objective is to take care - of humans, of the ecological system, of the earth - by considering the coloring matters coming from plants as medicines or quite simply good for the skin, as a serious alternative to petrochemical dyes.

New developments are made by young designers, with some collaborations, as examples: natural dye process for leather, innovative vegetable leather and colors, development of color ranges made with local plants, archeology of colors for new patterns, slow extraction process for weak dyes...

The author will also introduce a new collaborative program of research on the concept of «color & care», specifically questioning the color materials made with medicinal and dye plants. From a corpus about symbolic and traditional uses of colors (ancient practices and local know how), one of the objectives would be to prove the medicinal potential of some dyed samples with plants, through collaboration with chemists, and to develop some new ways of caring with colors.

## Chromatic Plans for Urban Furniture: the case of multicoloured urban zones

Margarida Gamito<sup>a\*</sup>, Joana Sousa<sup>a</sup>

<sup>a</sup>CIAUD, Lisbon School of Architecture, Universidade de Lisboa  
\*Corresponding author: margamito@gmail.com

All over the world, the concept of sustainable cities became inseparable from the concern with the population comfort. Social sustainability goes beyond the simple choice of materials. It must include the well-being of the entire urban population and must be supported by a coherent sustainable design.

In order to promote the connections among people and the relation between people and places, sustainable design, and particularly, sustainable urban design, must include landscaping and urban planning; create structures and public spaces that will contribute to a better use of the city, reinforcing its identity.

An important part of the elements that make up the city, contributing to its identity and the comfort of its inhabitants, is the ensemble of urban furniture, although there is a tendency not to consider it as such. In fact, urban furniture accomplishes several functions, such as the function of bringing comfort, and providing information and wayshowing to every citizen. For this purpose, its elements must be clearly visible and legible, and color is an important component to accomplish these features, independently from its built material or form.

In a precedent research, we created a methodology that, through chromatic and brightness contrast, and through the establishment of dominant urban pallets, allowed the establishment of a scientific and coherent criterion for the urban furniture color.

Most cities, either modern or ancient, have a restrict variety of colors or an established chromatic plan that enables the establishment of a chromatic plan to urban furniture. However, many towns or urban zones, such as Burano in Italy, other fishing villages, or even some Irish towns, are constituted by such a variety of colors, that makes it impossible to establish a dominant chromatic pallet.

In these cases, the urban furniture plan must be achromatic, but simultaneously maintain a brightness contrast, in order to allow the accomplishment of its functions.

Consequently, in the present paper we aim to present some possible solutions to solve this problem, creating Urban Chromatic Plans that will allow a good visibility and legibility for urban furniture and, simultaneously, will be a sustainable factor that contributes to the wellbeing of these urban populations.

## SESSIONS 3 & 4

# COLOUR AND HERITAGE

### SESSION 3

**Material approach: past and future architecture, natural lighting, material and digital restoration, art materials, 3D digitization technologies...**

Part 1 011 013 019 023 143  
Part 2 047 052 092 145 146

### SESSION 4

**Cultural approach intangible heritage and knowhow, language, anthropology, teaching colour...**

Part 1 020 028 032 034 041  
Part 2 044 055 057 073 084

## Color in the archives or color archives

Alexia Raimondo<sup>a\*</sup>

<sup>a</sup>Archives nationales, Pierrefitte-sur-Seine, France  
<sup>\*</sup>Corresponding author: alexia.raimondo@culture.gouv.fr

The F/12 collection of the Archives nationales keeps the archives of the administration of commerce and industry from the 17<sup>th</sup> century to the mid-1960s. This administrative organization was born in 1700 with the creation of the Council of Commerce had for purpose to «knowing and procuring all that could be most advantageous to the commerce and manufactures of the kingdom». This purpose will animate the commercial and industrial administration during the following centuries.

This archives reflects the politic's attention for knowledge and encouragement of everything that could be favorable to French trade. This administration's interest explains the presence in this collection of a very large number of samples of various materials and particularly of textile samples.

Indeed, these archives illustrate the state's action on color. It results in acts of control over the productions of 18<sup>th</sup> century manufactures, but also the quality of colors examination; through the verification records of "bon teint" brands, or later, the processes used in factories.

But these files also show how color becomes a real administrative concern through the attention given to inventions and discoveries. The samples kept were sent by manufacturers, salespeople or ordinary citizens to the administration to validate their research, in exchange for a patent, for gratuities, or without expecting anything in return if not the pleasure of serving the kingdom, empire or republic. They show the interest which animated research on the new materials to be used for weaving and dyeing or the new dyeing procedures.

These samples, both archive documents and color archives, are a precious heritage for the knowledge of ancient fabrics. Their conservation is an essential issue, because they represent an essential source for the study of dyes, know-how and dye recipes for two centuries.

### KEYWORDS

archives | textiles | samples | dyes

## White paint and black color in the Middle Ages

Yves Morvan<sup>a\*</sup>

<sup>a</sup>Centre Français de la Couleur

\*Corresponding author: yves-m@hotmail.fr

Many medieval pictures show saint characters with a black face. Yet this color is paradoxical as it is the Devil's color, thus contrary to religious symbolism in the Middle Ages.

In the 1930s, several specialists came up with the opinion that dark color of Black Virgins was done by lead white oxidation. But this proposal was not taken seriously and considered to be not credible because they said that no chemical action could have caused such a deep darkness. However, it is this idea that I support in a book to be published by the Debaisieux editor. His provisional title is «Black Virgin. The enigma of their black color unveiled».

My talk is concerned with the causes of this unusual black color which are due to the very specific use of various colors including, primarily, lead white. Gold is usually kept for halos but can also become black, and this is one anomaly of which we have many examples.

I explain why so few Black Virgins were found before the 16<sup>th</sup> century, time when they were admitted such as Black Virgins and painted or repainted with deep black paint when they were white from the beginning or darkened by pollution. While there were already so many holy figures with black faces on the murals.

This presentation will be followed by the presentation of a dozen documents that I will comment on, while answering any questions from the audience.

### KEYWORDS

*middle ages | paint techniques | black virgins | mural painting*



## Colour design and dementia: Evidence-based strategies to enhance environmental visual literacy

An ineffective interface between the built environment and people living with dementia can become highly problematic. Recently, inappropriate environmental design was identified as one of the two most common triggers for severe behaviours in people living with dementia, the other being unidentified pain issues (Judd, 2016).

In light of the above, effective colour design beyond aesthetics is an imperative in respect to the design of spaces for people living with dementia. In these spaces, evidence-based colour design strategies can be implemented to improve environmental visual literacy. These colour design strategies can address a number of aims. Firstly, these strategies can enhance environmental visual literacy by maximizing opportunities for people living with dementia to 'read' and understand the built environment in a meaningful way. In doing so, these strategies also address the changes and challenges in visual perception often experienced by people living with dementia. In-situ future research will focus on the extent to which this aim is achieved and whether this strategy supports orientation and wayfinding initiatives.

In addition, another aim of evidence-based colour design strategies is to encourage and improve engagement, with the added intention of supporting a sense of wellbeing among people living with dementia. Furthermore, it is anticipated that techniques for developing and implementing effective colour design strategies may also address the imperatives of inclusivity and a user-centred approach to environmental colour design. It is in these ways that evidence-based colour design strategies can move interior colour design beyond aesthetics to a more meaningful and effective tool aimed at improving the experience, dignity and quality of life for people living with dementia.

### KEYWORDS

colour design | dementia design | environmental visual literacy | interior design

## Rediscover the faded colours of an 18<sup>th</sup> century tapestry kept in the Cité Internationale de la tapisserie in Aubusson (France).

Aurélie Mouniera<sup>a\*</sup>, Hortense de la Codre<sup>a</sup>,  
Charlotte Marembert<sup>b</sup>, Carole Biron<sup>a</sup>, Pauline Claisse<sup>a</sup>,  
Floréal Daniel<sup>a</sup>

<sup>a</sup>IRAMAT-CRP2A (UMR 5060 CNRS - University of Bordeaux Montaigne, Pessac

<sup>b</sup>Myrobolan, Teintures naturelles artisanales, Bruxelles

\*Corresponding author: aurelie.mounier@u-bordeaux-montaigne.fr

Aubusson located in the center of France is on the List of Intangible Cultural Heritage of Humanity by UNESCO since 2009. This quality label rewards a centuries-old tradition for the art of tapestry. The studied tapestry with the Brühl count's coat of arms, is a "Verdure" (landscape representation), a specialty of Aubusson characterized by a very high quality and fine weaving, dyeing, made mainly for abroad (dated from the mid-18<sup>th</sup> century; 7.32 x 4.5 m). Its restoration is in progress and allows the removal of the lining of the back. Analyses were done on each side of the tapestry. This rare opportunity offers the possibility to perform analyses and to compare results of both faces, to measure the alteration of dyes through colour measurements and to appreciate the original colours.

To identify materials, the first step was to found old dying recipes through treatises and literatures practiced in Aubusson, then Manufacture Royale. Informations were found in the Jombert treatise « Le teinturier parfait » (1716), « L'art de la teinture des laines et des étoffes de laine en grand teint et petit teint » (Hellot, 1750), « Art de la teinture en Soie » (Macquer, 1761) & « Eléments de l'art de la teinture » (Berthollet, 1791). According to the recipes, more than 300 model samples have been made by a dyer to obtain a large variety of colours in order to understand the role of each component on the colour result.

This colour chart was used to build a specific database of reference spectra measured with portable devices (hyperspectral imaging in the visible & near-infrared ranges, portable fluorimetry (LED $\mu$ SF) ...). This database is a prerequisite for the identification of the dyes used on the ancient tapestry thanks to a comparison of spectra.

A study of the fading was done to understand the mechanism of alteration and the fragility of the dyes. A protocol was established and the components assembled to design a system of aging, measure, control and follow the colour fading (xenon lamp, measure of the reflectance spectra, colour measurements...). First, the tests were conducted on blue wool standards (1 to 8, ISO 105 B02) and then, the study of 3 dyes commonly used (weld, madder and indigo) has been conducted. Finally, the results have been compared with colorimetric measurements taken on tapestry's both faces where an important fading was observed for the yellow dyes.

The characterization of the tapestries' materials has been done by in situ analyses. The complementarity of the techniques makes possible the identification of the fibres (silk, wool), dyes (weld, indigo, madder, tannin...) and mordants (alum, cream of tartar). The colour measurements showed a colour difference lower than 3 for the red, blue and brown while is higher than 7 for the green and 12 for the yellow. These observations can be explained by  $\mu$ fading tests whose demonstrate that weld is weaker and correspond to standard blue wool 1, madder fades like the blue wool 3 and the indigo appears very stable such as the blue wool 8.

All the results obtained in this 3 years' research program (2019-22) will help the digital reconstruction of the tapestry's colours, proposing a digital colours palette and a fresh digital dying of the tapestry. With the restoration in progress and the digital support available in the museum beside the exhibition of the tapestry, the visitors will be able to appreciate the colours of the 18<sup>th</sup> C. art of tapestry.

## Verification of the Validity of the Perceived Colour Measurement Method using Tablet Devices in Architecture

Haruno Tsuda<sup>a</sup>, Azusa Takei<sup>a</sup>, Nozomu Yoshizawa<sup>a</sup>,  
Kaoruko Kitamura<sup>b</sup>

<sup>a</sup>Tokyo University of Science, Japan

<sup>b</sup>Mukogawa Women's University, Japan

•Corresponding author: hyphen\_haru0505@outlook.jp

When we deal with colour in architecture, we can generally divide it to three types. One is the psychophysical colour under standard illuminants, which can be measured in a contact state using colorimeters. Another is the colour under actual lighting in architecture, where non-contact surface colour measurements are made using luminance and colour meters like CS-100. The other is perceived colour in real architecture, which is affected by the human perception system, such as light adaptation and colour contrast. The last type of colour is most important when we think of colour experience in architecture, which changes over time and takes on various appearances under variable sunlight. However, its measurement is always difficult in the field survey. Colour-naming methods is yet unclear whether the subtle difference of colour perception by naïve observers could be fully grasped. Conventional colour-matching methods using colour charts need large-sized apparatus and it is sometimes difficult to bring it to measurement locations. We tried to use portable tablet devices instead of usual paper-made colour charts and verified the validity of this method for measuring perceived colour through a subjective experiment.

The tablet device was covered by a black box to cut the surrounding light and observers see its screen through a small opening. An observer selected the colour on the tablet which was judged to be the same as the perceived colour on the target in architecture. After the field survey the spectral distribution of the selected colour on the screen was measured using a spectral radiance meter.

In this research the individual differences of the colour matching results by this method was examined compared with the surface colour measurement method (visual colorimetry), prescribed in ISO/DIS 3668, in which colour chips are put next to the target as a reference. In the experimental room, a colour chip was presented as evaluation colour on a background surface. Evaluation colours of the target had four levels, such as 9PB7.5/3.0, 8YR9/2, N9.5, N7.0. Colours of the background surface were N5, 5B4/5, 3GY5.5/5.5 and 10R5/6.5. Correlated colour temperatures of incident light were 6500K and 3000K, and illuminances on the target were 1000lx and 500lx. 19 subjects, aged early 20's with normal colour vision, evaluated the colour of the target by both methods above.

The individual differences were compared based on the distances among the points of evaluated values described in CIE 1976 L'u'v'. The experimental results showed that, when correlated color temperature was 6500K and illuminance was 1000lx, individual differences of the colour evaluation by the new method using a tablet device were as small as the conventional visual colorimetry. The method proposed in this research had the enough validity for measuring perceived colour in architecture under sufficient daylight in the daytime, and we have actually measured some subtle changes of white in more than 50 buildings, which were built between 1932 and 2019. However, when correlated colour temperature was 3000K, individual differences became larger and it is necessary to find the cause in future works.

### KEYWORDS

perceived colour | architecture | colour measurement | tablet devices

## Colour Planning in Cilento: project and methodology

Claudia Lombardi<sup>ab</sup>, Klarissa Pica<sup>a\*</sup>

<sup>a</sup>Kumea srl, Napoli, Italia

<sup>b</sup>Universidad Politécnica de Madrid, ETSEM, Madrid, España

<sup>c</sup>Università IUAV di Venezia, Venezia, Italia

\*Corresponding author: kp@kumea.it

This work talks about the experience of a colour planning in the Cilento territory and, exactly, in the city of San Mauro Cilento. The aim is to focus attention on the role assumed by the Colour Planning as an urban planning tool that aims to protect the identity and culture of places with a particular attention to redevelopment and environmental enhancement.

Urban colour planning's aim is to give back a new image of cities by defining not only the façades colours and all the elements that make it up but, above all, rules for the existing building heritage conservation and protection in order to enhance the urban landscape. Throughout the analysis of the urban fabric, building typologies, architectural elements and colours used in the past, the colour plan aims at defining of new cities urban design, respecting their historical peculiarities and traditional elements.

The city of San Mauro Cilento, over the years, has witnessed a progressive alteration of external decorum related to the historical urban fabric. This has led to the loss of the peculiar signs of the place and of the original materials that has caused a devaluation of the quality of urban environment.

San Mauro Cilento, although not very extended and with a few inhabitants, has decided to use this urban planning tool to recycle and rebuild the original colour ranges and colour models of the buildings and, at the same time, make a technological and compositional evolution of the façades. In this way, progress factors, environmental conditions and relations with contiguous and opposite façades are taken into account, formulating precise basic compositional criteria.

The plan aims to regulate the interventions on the façades in relation to the composition of the elevations, the technologies and materials used and the adoption of a colour palette compatible with the chromatic characteristics historical settlements of the city.

Two steps were fundamental to the implementation of the plan. The first concerns interviews with the local personalities who had worked as «masters» in the past, in order to acquire additional information about local building techniques and materials. The second one, concerns the use, in the second phase of the survey, of an NCS instrument, ColourPin II, through which a scan of the colours present on the building's façades, was made paying particular attention to the research of the original colours and not altered by external agents.

Exceptionalities of this plan are the methodology applied for definition of the colour palettes and the design of the colour of every single facade, which can be created with extreme freedom within the chosen colour ranges but, at the same time, must respect a rigorous approach to the colours matching.

### KEYWORDS

colour planning | San Mauro Cilento | identity | palette | colours

## Preliminary study of the reconversion of darkened pigments (lead white, cinnabar) in mural paintings by Nd:YAG laser irradiation

Victor de Seauve<sup>a\*</sup>, Alexandre Semerok<sup>b</sup>, Olivier Grauby<sup>c</sup>, Vincent Detalle<sup>d</sup>, Jean-Marc Vallet<sup>a</sup>

<sup>a</sup>Centre Interdisciplinaire de Conservation et Restauration du Patrimoine (CICRP), 21 rue Guibal, 13003 Marseille

<sup>b</sup>Des - Service d'Etudes Analytiques et de Réactivité des Surfaces (SEARS), CEA, Université Paris-Saclay, F-91191, Gif sur Yvette, France

<sup>c</sup>Aix-Marseille Université, CNRS - UMR 7325 CINaM, campus de Luminy, Case 913, 13288 Marseille Cedex 9, France

<sup>d</sup>C2RMF, Palais du Louvre - Porte des Lions, 14, quai François Mitterrand, 75001 Paris

\*Corresponding author: victor.de-seauve@cicrp.fr

Lead white ( $2\text{PbCO}_3\text{-Pb(OH)}_2$ ) and red cinnabar ( $\alpha\text{-HgS}$ ) are two pigments commonly found in mural paintings. In some conditions however they darken, inducing visual consequences to the artworks. The darkening of lead white is usually attributed to the formation of black plattnerite ( $\alpha\text{-PbO}_2$ ).<sup>[1,2]</sup> For cinnabar, the formation of successive layers of chlorinated and sulfochlorinated mercury phases, such as greyish corderoite ( $\alpha\text{-Hg}_3\text{S}_2\text{Cl}_2$ ) and calomel ( $\text{Hg}_2\text{Cl}_2$ ) was evidenced from experimental and theoretical experiments; the black color would then be ascribed to the formation of metallic mercury.<sup>[3,4]</sup> Few methods of restoration of blackened lead white have been tested, most of them involving chemical treatments which put the support at risks.<sup>[1]</sup> On the other hand Nd:YAG and Ar<sup>+</sup> lasers irradiation has been successfully applied to the safe reconversion of blackened minium ( $\text{Pb}_3\text{O}_4$ ), also due to its degradation into plattnerite.<sup>[5]</sup> Within the objective of developing a restoration-oriented tool, the specific aim of this study is to explore the possible reconversion of darkened lead white and cinnabar by Nd:YAG laser irradiation in an experimental way.

Samples consist in pure artificially aged cinnabar and plattnerite powders pressed into pellets. Plattnerite-based mural painting samples and experimentally darkened cinnabar ones have also been prepared in the lab by various techniques. Appropriated conversion temperatures have been determined in various atmospheric conditions ( $\text{CO}_2/\text{H}_2\text{O}/\text{air}$  for plattnerite and  $\text{H}_2\text{S}/\text{air}$  for darkened cinnabar) by means of thermogravimetric analyses (TGA). Then, an experimental setup has been designed so that the samples were simultaneously exposed to the gas flows and the laser beam. Irradiation times and laser power density have been adjusted from TGA results. The visual consequences of laser irradiation were determined from UV-visible reflectance measurements which allowed calculating colorimetric coordinates in the CIELAB space. The reconverted thickness was determined by optical microscopy and its influence on the visual aspect of the sample was investigated. Lastly the identification of the chemical species was achieved by means of XRD.

[1] S. Giovannoni | M. Matteini | A. Moles | *Studies in Conservation* 1990 | 35 | 21–25.

[2] E. Kotulanová | P. Bezdička | D. Hradil | J. Hradilová | S. Švarcová | T. Grygar | *Journal of Cultural Heritage* 2009 | 10 | 367–378.

[3] M. Radepon | Y. Coquinot | K. Janssens | J.-J. Ezrati | W. de Nolf | M. Cotte | *J. Anal. At. Spectrom.* 2015 | 30 | 599–612.

[4] M. K. Neiman | M. Balonis | I. Kakoulli | *Appl. Phys. A* 2015 | 121 | 915–938.

[5] S. Aze | P. Delaporte | J.-M. Vallet | V. Detalle | O. Grauby | A. Baronnet | in *Proceedings of the International Conference LACONA VII* | CRC Press | Madrid | 2007 | pp. 11–13.

### KEYWORDS

cinnabar | lead white | darkening | Nd:YAG | restoration

## The Impact of Surface Properties on Photovoltaics' Colour Angular Sensitivity- A Comparison Study for Facade Integration

Changying Xiang<sup>a\*</sup>, Phil Green<sup>b</sup>,  
Barbara Szybinska Matusiak<sup>a</sup>

<sup>a</sup>Norwegian University of Science and Technology, Trondheim, Norway

<sup>b</sup>Norwegian University of Science and Technology, Gjøvik, Norway

\*Corresponding author: changying.xiang@ntnu.no

Façade Integrated Photovoltaics (FIPVs) is a new promising trend to employ clear energy in built environment. The colours of FIPVs are essential to the overall aesthetic quality of buildings, especially in the urban context. Currently, several brands of coloured PVs are available on the market. However, unlike traditional façade materials, the colorimetric characteristics of coloured PVs are barely studied. To provide a foundation for further aesthetic research on FIPVs and to develop a guideline for architectural design with FIPV, a series of colour angular sensitivity experiments are carried out for testing of 6 different types of opaque coloured PVs. PV samples are measured at different viewing angles with a PR-655 spectroradiometer through a series of laboratory and outdoor experiments. The experimental results show that the surface properties including colour techniques, texture and finishing glossiness have a strong impact on PV's colour angular sensitivity. Goniochromism has been found in a sample with interference coating technique (Kromatix PV) and a sample with anti-reflective coatings showing metallic texture (LOF metallic PV), while a sample with selective filter technique and low glossy rough finishing (ISSOL PV) shows angular insensitivity for hue in different illumination conditions. Its multi-layered selective filters reflect part of the visible light for the desired colour and transmit infrared rays to the solar cell layer for energy production. Samples with mineral coating techniques (Sunage PVs) show colour angular insensitivity in overcast illumination, while matt finishing leads to larger colour angular difference than glossy finishing in direct sunlight illumination.

Based on experimental findings, the study proposes a series of architectural design ideas for integration of different coloured FIPVs in different urban contexts accordance to their colour angular sensitivities.

This study provides new information for FIPVs design, especially for architects who would like to apply the colour FIPVs in their designs. In order to meet the specific colour design expectation, the color techniques and surface property of photovoltaics also needs to be considered.

### KEYWORDS

FIPV | architectural design | goniochromism | colour difference | angular sensitivity

## The contribution of diffuse reflectance on the knowledge of prehistoric red coloring matter

Emilie Chalmin<sup>a\*</sup>, Bernard Schmitt<sup>b</sup>, Claire Chanteraud<sup>a</sup>, Aurélie Chassin de Kergommeaux<sup>a</sup>, Fayçal Soufi<sup>a</sup>, Hélène Salomon<sup>a</sup>

<sup>a</sup>Univ. Savoie Mont Blanc, CNRS, EDYTEM (UMR 5204), Le Bourget du Lac, France

<sup>b</sup>Univ. Grenoble Alpes, CNRS, IPAG (UMR 5274), Grenoble, France

\*Corresponding author: emilie.chalmin-aljanabi@univ-smb.fr

The red color is one of the most ancient color used by the humanity to paint or draw on different kinds of surface (wall, rock, skin, wood, shell...). Even if this red color could be obtained easily with ferruginous rock during the prehistoric time, several questions still remain to identify this matter and its origin and to understand its transformation. Indeed, numerous remains of colouring matter, often referred to as ochre, have been found in the archaeological sequences. They come in the form of cohesive blocks of rock, powder or material applied to various supports. Beyond their use as colouring matter, traces of their use suggest other uses for technical purposes (e.g. treatment of skins, polishing).

The collective research project Pigmentothèque (PCR, DRAC Auvergne-Rhône-Alpes) proposes to respond to dual archaeological and methodological challenges:

- understanding the functioning of the paleo-society thanks to the study of the coloring matter, which retain the processing techniques used to exploit them, providing access to certain parts of the technical systems.
- to highlight the other information recorded in the coloring matter such as the conditions of their genesis and evolution before selection by human groups.

Unfortunately, the reading of archaeological colored and coloring matter is not always easy, because powdering, alteration or the nature of the rock blurs the tracks of its geological or even geographical origin. For this reason, a robust methodological approach is required.

From 2016, more than one hundred blocks of ferruginous rock coming from the Ardèche and Gard valleys have been collected in the landscape thanks to geological documentation and prospections. This collection is the subject of a petrographic description based on a shared vocabulary (lexicon). Moreover, structural and geochemical characterization is still in progress by developing robust methodology based on the acquisition of data on shared standards with several analytical tools, compatible with the constraints related to archaeological objects.

During the year 2019, we were able to access the facilities of 2 spectro-gonio radiometers of the IPAG laboratory (Institute of Planetology and Astrophysics of Grenoble, UGA) to characterize the reflectance of a selection of ferruginous rocks, presenting varied compositions and a wide range of red and yellow hues. These experimental devices allow the acquisition of reflectance spectra in the visible and infrared range (0.35 - 4.8µm) over a wide range of illumination (0-80°) and observation angles (emergence: 0-80°, azimuth 0-180°). Thanks to this facility, we investigate the possibility to understand the diversity of the reflectance and spectral signature of the different samples and to make correlation with the diversity of mineral phase associations. In fact, in addition to documenting and measuring the colour characteristics of materials, the spectral reflectance presents several absorption bands sensitive to the nature of the various constituent phases, whether it be the presence of chromogenic minerals (hematite, goethite, maghemite, etc.) or the presence of other associated minerals. A first classification of the samples was carried out on the basis of the different structures and spectral signatures.

## Chromatic identity of the urban tile panels: the scenario of Lisbon subway stations.

Cristina Caramelo Gomes<sup>a\*</sup>, Margarida Gamito<sup>b</sup>

<sup>a</sup>CITAD, Lusíada University of Lisbon, Rua da Junqueira, 188-198, 1349-001 Lisboa, Portugal

<sup>ab</sup>CIAUD, Lisbon School of Architecture, Universidade de Lisboa, Rua Sá Nogueira, 1349-063 Lisboa, Portugal.

<sup>b</sup>Portuguese Colour Association, Lisbon, Portugal.

\*Corresponding author: Cris\_caramelo@netcabo.pt

The city is a living organism characterized by its economic, social and cultural dynamics.

Metropolitan cities are becoming smart environments and this concept strongly relates to the cultural identity of the place and the mechanisms that improve user interactions throughout the delight of the experience. Colour is a significant element of the identity of the place, as well as contribute to the user's experience of the place.

The different experiences, ways of life and human interactions are significant components of the place's identity. This is granted by built environment, geographical location and orientation, the shape of buildings and equipment (as well as the finishing materials identifiers of constructive processes and / or traditional materials), cultures and contemporaneous trends.

With the city of Lisbon as a backdrop scenario, it is possible to explore its urban tissue and identify the different cultures or the sequential gentrification processes that Lisbon suffered from the first millennium, with particular emphasis on the Arab occupation and its tiling mode – adding a new skin to the facades - featured by its geometric and chromatic patterns.

In spite of such cultural heritage, the last decades witnessed a proliferation of achromatic paletas to respond to modernism requirements and trends that follow acknowledged names of Portuguese architecture.

Therefore, the tile panels were relegated to mural panels on city crossing points and subway stations, acting like a tattoo on the built skin, with monochromatic and / or polychromatic graphics pattern, contributing to a figurative and symbolic image of the place.

Smart cities aim to develop new ways of transportation, and the public ones, such as the subway, emphasizes their importance. Subway stations are places where a considerable number of individuals interact with the space and with each other while waiting for transport. The ambience provided is of major importance to ease waiting times as well as overcrowding at peak times.

More than the finishing of the building, the wall and / or the object, tiles panels are constituents of semiotics and Lisbon's imagery, and subway stations are one active part of the city.

This paper aims to create a deeper understanding of the influence of the tile's panels to the image (graphic and symbolic) of the Lisbon subway stations, and their input to qualify user experience. For that, some study cases (representative of the chronological age of the subway stations) will be analysed (focused on defining and registering the predominant colours, on the message associated with the graphics represented, the reason beyond their choice and application, as well as their contribute to for the feeling of security, visual comfort, orientation and aesthetic pleasure of the user) to a broader understanding and further discussion.

### KEYWORDS

*tiles chromaticity and patterns | smart cities | semiotics | imagery | subway stations of Lisbon*



## Reframing colour within the context of design education: Applying Q-methodology to enhance insight and learning

Zena O'Connor, PhD

Design Research Associates, Sydney, Australia  
Corresponding author: zena@zenaoconnor.com.au

Exploring colour within the context of design education is challenging for a range of reasons. Firstly, the literature on colour is awash with a plethora of colour theories drawn from different fields of research including phenomenology, psychology, physics, art and design. These often include guidelines and formulae aimed at informing colour application. In addition to these theories, information available across mainstream media is highly variable and includes a jumble of theories that often lack consensus or peer-review, as well as personal beliefs masquerading as theory. Despite this clutter of colour theories, design education has an imperative to provide colour application insight that has relevance across all areas of design including architectural design.

This paper describes a new approach to colour curriculum with the context of design education. Under this approach, students use Q-methodology to explore, compare and contrast a range of colour constructs using visual stimuli. Q-methodology (including Q-sort and F-sort techniques) is frequently used in social and educational research, and in this instance, participants use this methodology to explore colour constructs and relationships by sorting visual stimuli according to a set of self-generated (F-sort) as well as pre-determined (Q-sort) colour constructs, the latter of which may include constructs such as 'analogous colour' and 'contrasting colour'. The visual stimuli specified for this approach is a set of cards, the colours of which are linked to common colour notation systems frequently used in the design sector including the NCS and Munsell colour systems, and specified using hex codes. The colour card set features a comprehensive range of hues in a wide range of tonal values and saturation levels, as well as achromatic colours including white, black and greys.

Based on methodology used in research projects by the author since 2008 and applied in university design and architecture education since 2015, it is clear that this approach has a number of key benefits. Firstly, students gain the opportunity to examine colour in an experiential, exploratory and non-judgmental context. Secondly, students become aware of variability of cognitive evaluations and affective appraisals in respect to colour among their peers. In addition, students discover and document their own beliefs as well as possible biases about key colour constructs and colour application formulae. Finally, students gain valuable insight when examining patterns of similarity and difference in respect to colour construct clusters among their peers. Q-methodology in this context provides students with invaluable insight into common colour theory constructs beyond rigid colour theory. The insight gained from this approach provides design students with a greater depth of knowledge about colour relevant to design praxis. The use of hex codes also provides students with the capacity to communicate colour from traditional substance colour and formula colour through to digital colour, and across a range of platforms.

### KEYWORDS

*colour theory | colour education | colour application | design education | architectural design*

## **The teaching of color applied to design: a didactic sequence proposal for a reflexive process of selection and use of colors in projects.**

Camila Assis Peres Silva

Federal University of Campina Grande, Campina Grande, Paraíba  
Corresponding author: [silva.camila.assis@gmail.com](mailto:silva.camila.assis@gmail.com)

From this article, I discuss the teaching of color for design courses. Specifically, regarding training design students to select and use colors in their projects. After all, color is a fundamental visual element in the conception of products. Given the breadth of the field of knowledge of color, which runs through physics, chemistry, art and psychology, I understand that a challenge is imposed on those who teach about colors for design.

Considering design bachelors, the teaching of color occurs at the beginning of the course based on the premise that it is a basis for design, such as the teaching of visual language, art history and design, among others. The teaching of color usually covers the fundamentals, about color classification, color dimensions and the accuracy of the student's gaze. They are stimulated to manipulate chromatic mixtures in order to recognize the different nuances of a color, as well as order them. In addition, the student learns to use color combinations and understands the psychological effects that a color can have on its viewer. This last topic is perhaps the most important in design practice.

In order to contribute to the optimization of the teaching of color applied to design projects, I present in this work a methodology that has been developed and improved in the last five years. It is a didactic sequence in which the student is guided from the thematic selection of color to the possibilities of application in the project. Along this path, he explores the psychological aspects while evaluating possible color combinations based on understanding the relationships of clarity and hue. It is also a didactic sequence that can be applied to students of more basic levels as well as technical courses to more advanced levels such as postgraduate. The final goal is that the process of selecting and using color is less intuitive and more reflective.

### **KEYWORDS**

teaching | design | color | didactic

## Colour Preferences in Japanese Kindergarteners

Noriko Suzuki<sup>a\*</sup>

<sup>a</sup>Showa Women's University, Tokyo, Japan  
\*Corresponding author: n-suzuki@swu.ac.jp

### Background

Although Japanese children's colour preferences have been analysed by making them select from colour samples (Saito 2010), in this study, preferences were analysed by asking children to name the colour.

### Methods

Semi-structured interviews regarding colour preferences and reasons for these preferences were conducted with 39 children (18 boys and 21 girls) between the ages of 5 years 10 months and 6 years 10 months enrolled in two private kindergartens in Tokyo. In all, 13 boys and 17 girls participated from Kindergarten A, and 5 boys and 4 girls participated from Kindergarten B.

### Purpose

The study's purpose was to identify Japanese children's colour preferences when they were asked to name the colour.

### Results

1. Children used non standard names for colours and also invented names for them.
2. While there was no difference in the boys' preferences across both kindergartens, differences were observed in the girls' preferences.
3. A significant difference was observed in the boys' and girls' colour preferences. In Kindergarten A, black was most popular among the boys and least popular among the girls, while pink was most preferred by the girls and least by the boys.

### Discussion

Among the responses were colours with unconventional names, such as 'rainbow colour' and 'colour of the evening'. By 'colour of the evening', participants referred to the colour of the evening sky. In all, 20% of the participants indicated that their favourite colour was 'ao' (the Japanese word for blue), 'buruu' (the Japanese-English word for blue), 'mizuiro' (light blue), or 'sorairo' (sky blue), which, without exception, was associated with the sky.

Moreover, 76% of the boys in both kindergartens chose black as their favourite colour, and 55% selected pink as their least favourite colour. On the other hand, for girls, there were significant differences between the kindergartens, with 58% of girls in Kindergarten A favouring pink, and 50% of the girls in Kindergarten B favouring brown. Furthermore, in Kindergarten A, black was most popular among the boys and most hated by the girls (41%), while pink was most popular among the girls and disliked most by the boys (69%).

The participants associated various words for blue with the sky, and girls in Kindergarten B explained that they liked brown as it was the colour of trees. In addition, the reason boys in both kindergartens preferred black and girls preferred pink was that these colours were associated with items worn by heroes and heroines in Japanese anime films, which made them 'so cool' or 'so cute'. The results confirmed that children's colour preferences were formed on the basis of gender cues and their interest in things resembling nature, such as the sky and trees. To investigate why there were no differences in boys' preferences between both kindergartens as opposed to why differences in girls' preferences existed will require a study with a larger sample.

## The philosophy of colour in the French period of environmental colour design

Verena M. Schindler<sup>ad</sup>\*, Yulia A. Griber<sup>bd</sup>,  
Martine Bouchier<sup>c</sup>

<sup>a</sup>Art and Architectural Historian, Zollikon, Switzerland

<sup>b</sup>Smolensk State University, Smolensk, Russia

<sup>c</sup>École nationale supérieure d'architecture de Paris-Val de Seine, Paris, France

<sup>d</sup>Co-Chair of the AIC Study Group on Environmental Colour Design

\*Corresponding author: ecd.studygroup@yahoo.com

This paper discusses the second part of the results of a research project on the French period in the history of environmental colour design. The first part was presented at the AIC 2019 conference in Buenos Aires. In France of the 1950s and 1960s, colour provided a new understanding of the environment. In the aftermath of World War II, the economic, societal and cultural dynamics led to the birth of the new profession of the colour consultant. The research method of the present project followed a qualitative oral history approach that involved a series of semi-structured interviews with six renowned French colour consultants who carried out colour research and created colour projects that had a great impact on new towns, historical city centers, public spaces, and urban environments. The interviews were conducted and video-recorded in May 2019 in Paris in the studios of the interviewees Michel Albert-Vanel, Yves Charnay, Victor Grillo, Bernard Lassus, André Lemonnier, and Jean-Philippe Lenclos. The topic guidelines for the interviews included two groups of exploratory, open-ended questions. The first group of questions concerned the main sources and significant intellectual influences on the interviewees. The second group of questions – discussed in this paper – addressed the meaning, focus, and philosophical insights of environmental colour design, its evolution, materiality and practice. Applying an inductive approach and implementing a 'thematic analysis' for the interpretation and representation of the interview data, patterns were identified and studied. They provided depth and details to the general picture of the history and key aspects of the evolution of environmental colour design. The results of the research project contribute to our understanding of theoretical, conceptual and methodological approaches of colour in environmental colour design. A short video will be presented.

### KEYWORDS

*environmental colour design | colour consultant | colour designer | colour methodology | French context*

## Characterization of cultural heritage objects from South Benin. What do we know about the natural dyes used in their manufacture?

Louis Fagbohoun<sup>a</sup>, Carole Mathe<sup>b</sup>, Fernand Gbaguidi<sup>c</sup>,  
Marc Ayedoun<sup>c</sup>, Cathy Vieillescazes<sup>b</sup>

<sup>a</sup>Higher Normal School of Natitingou, UNSTIM-Benin

<sup>b</sup>Avignon University, UMR IMBE, CNRS 7263, IRD 237, Avignon-France

<sup>c</sup>Abomey-Calavi University, IREMPT, CBRSI, Benin

\*Corresponding author: fadis07@yahoo.fr

Colors are practically omnipresent in artistic and craft objects from the Yoruba cultural area. Apart from the usual ochres and kaolin, the paint layers of the sculptures are little known, particularly in terms of the dyes and plant binders used. Note that traditional knowledge linked to the extraction and use of natural dyes is disappearing, with the worldwide spread of «European» lifestyles. Originally, the dye materials used in the making of heritage objects gave them life and contributed to their identity.

This work is in the context of museums and aims to identify the dyes formerly used in the manufacture of painted objects from the Yoruba cultural area in order to help the work of curators and restorers as well as to save and enhance ethnic objects on the flourishing art market. Indeed, the determination of the sources of dyes allows access to an intrinsic knowledge of museum objects, and opens up on the history of these pieces, their place of manufacture, their meaning and their value.

About twenty dye samples from collections of museum objects, including guèlèdè masks, fetishes and statuettes of ibeji twins, were analyzed by infrared spectroscopy (FT-IR) and by liquid chromatography (HPLC-PDA), as well only by microchemical tests. These analytical techniques permit to characterize via the identification of specific markers / molecules, such as 2-hydroxy -1,4-naphthoquinone, apigenin, epicatechin, indigotin etc., tinctorial plants such as, *Lawsonia inermis*, *Khaya senegalensis*..., in the red samples, as well as *Philenoptera cyanescens*, and *Indigofera tinctoria*, in some blue samples. In addition, the characterization of mineral ions such as  $Al^{3+}$ ,  $S^{2-}$ ,  $Fe^{3+}$  and  $Fe^{2+}$ ; showed that natural pigments such as iron oxides, and synthetic pigments such as washing blue, Prussian blue, etc., were used pure or mixed in the making of certain objects. Indeed, it emerges from the stratigraphic analysis of the pictorial layers, a diversity of dyeing techniques for ethnic objects. Some stains are applied directly to wood, while others are used as a formulation; mixed or layered.

Moreover, the application of dyes to specific locations on some objects denotes coded know-how which reveals that their role goes beyond the decorative function. This result will make possible the conservation and the restoration of the studied objects, by using original materials, while ensuring their visual and functional integrity.

### KEYWORDS

heritage | dyes | origin | conservation-restoration | Yoruba

## Less is more – a new approach to colour

Barbara Diethelm

Lascaux Colours & Restauro, Barbara Diethelm AG, CH-8306 Brüttisellen, Switzerland  
Corresponding author: b.diethelm@lascaux.ch

As a paintmaker and artist one of my major concerns is colour harmonies. In 1995, I started to research and develop an expanded colour system based on five primary colours, instead of the usual three. It was patented as a five-colour theory by the European Patent Office in 2001. Produced as material colours, artist colours, it is available since 25 years as Sirius Primary System.

Mixed in equal parts, the five primary colours, magenta, red, yellow, cyan and ultramarine, produce a vibrant neutral black. An additional White rounds off the system. The colours maintain their chroma in unlimited ranges of mixtures: from secondary and tertiary colours to earth and pastel tones.

A colour system without discrepancy between theory and practice. With this unique colour concept, the entire spectrum can be mixed harmoniously, resulting in pure and vibrant mixtures. The 360-part Sirius colour wheel turned out to be a ground-breaking undertaking. Unachievable with conventional colour systems, it was accomplished for the first time with Sirius Primary Systems.

The fact that the entire spectrum can be mixed with the use of only five colours, yields not only a very pleasurable introduction to painting with wet paints but offers a great advantage from an economical point of view – THE USE OF LESS.

The luminous primary colours inspire colour mixing. Due to their purity and balanced frequencies they allow a precise mixing of an unlimited range of harmonious and differentiated nuances and individual colour schemes. Such a multitude of subtle and differentiated nuances promote a highly subtle and differentiated perception.

Lively and vibrant colours are used in all areas in which, beyond the visual, the sensual quality of colour is to be perceived and in all processes where an expressive, creative use of colour is defined as the primary task: Colour theory, Art and Design, Colour concepts and Architecture.

In my presentation I explore these colour harmonies in their practical applications, showing how they have been successfully used in paintings, sculpture and architectural concepts. From the many projects realised worldwide, in private as well as public rooms, indoors as well as outdoors, I have selected five projects: They exemplify how the transparency and brilliance of the colours, often applied in glazing and washing techniques, lend buildings volume; convey an atmosphere of joy, beauty and harmony to every space. They show how a coherent colour scheme can be achieved by shades and tints which retain their full chroma. And moreover, superbly capturing how a minimal range of a few intense colours can maximize aesthetic value. LESS IS MORE.

### KEYWORDS

pigments | colour theory & harmonies | murals | art & architecture

## À la recherche des sources techniques de la teinture

Marie-Anne Sarda<sup>a</sup>, Clémence Lescuyer<sup>b</sup>,  
Alexia Raimondo<sup>b</sup>

<sup>a</sup>Institut national d'histoire de l'art, Paris, France

<sup>b</sup>Archives nationales, Pierrefitte-sur-Seine cedex, France

\*Corresponding author: marie-anne.sarda@inha.fr

Alors que l'invention des colorants de synthèse au cours de la seconde moitié du XIX<sup>e</sup> siècle est l'une des plus célèbres découvertes scientifiques européennes de l'époque, la transition quant à l'usage dans le textile des teintures naturelles et/ou des colorants de synthèse reste largement méconnue. L'Institut national d'histoire de l'art a ouvert en 2017 un programme de recherche consacré aux colorants utilisés de 1850 à 1914 qui croise histoire des arts, histoire industrielle et histoire des sciences et des techniques.

L'un des aspects transversaux de ce programme est de rassembler et de mettre à disposition des chercheurs les sources techniques de la pratique de la teinture naturelle de la fin du Moyen Âge au début du XX<sup>e</sup> siècle, la connaissance de ces sources apparaissant en effet indispensable à une analyse critique des apports des premiers colorants de synthèse. Mené en partenariat avec les Archives Nationales, ce recensement prend en compte les traités de teinture, manuels de teinturiers et tout document manuscrit abordant un ou plusieurs procédés de teinture. Eventuellement assorties d'échantillons de fibre ou de textile teint, les sources manuscrites retenues dans le recensement sont conservées dans les collections publiques françaises : centres d'archives, bibliothèques et musées.

Livre d'ouvrage de teinture de Frédéric Chana (1736-1745), procès-verbal d'opérations de teintures faites à Yvetot en 1756, correspondance sur la teinture à l'écarlate adressée à l'Intendance d'Amiens de 1760, rapports et échantillons de teinture préparée en 1787 avec la cochenille de Saint-Domingue, documents sur la teinture et mémoires de teinturiers ayant appartenu à Antoine Laurent de Jussieu et à Pierre Joseph Macquer, manuscrit du teinturier imprimeur Claude Baron destiné à son neveu (1784-1795), livre de teinture de 1820 de la manufacture Dollfus et Huguenin écrit en alsacien, livre de recettes de 1827 du maître teinturier Jacques Chevallet, mémoire du manufacturier chimiste Charles-Alexandre Broquette, correspondances entre Camille et Horace Koechlin, notes sur l'aniline de Gobert Dalsace, journaux de laboratoire dispersés de Léonard Schwartz, livre de teinture d'Emile Blondel (1862-1865) : après une rapide présentation des principes d'indexation, la conférence donnera quelques exemples des pépites rencontrées au cours de ce recensement.

### KEYWORDS

manuscrit | procédé | colorant | teinturier

## Optimized visualization of Château de Germolles' wall paintings using mobile augmented reality with co-lighting

Jean-Philippe Farrugia<sup>ab\*</sup>, Christian Degriigny<sup>c</sup>

<sup>a</sup>IUT Lyon-1, département Informatique, F-01000 Bourg-en-Bresse

<sup>b</sup>Université de Lyon, CNRS, université Lyon-1, LIRIS, UMR5205, F-69622 Lyon

<sup>c</sup>Christian Degriigny, Haute Ecole Arc Conservation-Restoration, HES-SO Haute Ecole Spécialisée de Suisse Occidentale, 2000 Neuchâtel, Suisse

\*Corresponding author: jean-philippe.farrugia@univ-lyon1.fr

The Château de Germolles, offered to Margaret of Flanders by her husband Philip the Bold, Duke of Burgundy and brother of King Charles V of France, is both the best-preserved residence of these Valois princes, and the one that still displays unique wall paintings from the end of the 14<sup>th</sup> century. Rediscovered during World War II, the paintings were partially conserved between 1989 and 1994. This intervention, although quite respectful, was not documented. Thanks to archival records and careful examination of the residual decorations, the painting technique could be better understood, including the application of metal decorations, which residues were partly masked during the conservation intervention. A slight de-restoration would allow their recovery but would not improve the current rendering.

The public visiting the Château de Germolles and discovering these painted decorations is far from imagining the sumptuousness of their original appearance, despite the information provided. An augmented reality application consisting of a cross-fade between two scenes, actual and virtual, the latter reproducing as faithfully as possible the hypothetical decor was therefore created. It uses a light and nomadic support (tablet), is non-intrusive (no visible markers or location devices) and easy to use. It is, moreover, entirely controlled by the person guiding the visitors: it is indeed an accompaniment to the speech. While the application addresses the issue of co-location, those of co-occultation (i.e. considering respective geometric occultation between real and virtual elements of the scenery) and co-lighting remain to be considered. This article focuses more particularly on the latter point.

The co-lighting problem consists in calculating the lighting interactions between real and virtual elements. Within the framework of this project, the scientific and technical challenge of co-lighting is multiple. Firstly, it was necessary to reconcile a physically plausible ambient lighting calculation in real time with the limited computational resources of a tablet. This was achieved using the Unity 3D framework with physically-based reflectance models suited for mobile usage. Second, data acquisition for ambient lighting had to be possible without specific and/or intrusive hardware. We chose to use HDR panoramic environment maps. Finally, the materials constituting the wall paintings had to be compatible with the rendering pipeline. In order to ensure compatibility and ease of editing, these materials were designed based on newly acquired knowledge with the Substance Designer editing software, in order to propose rendering hypotheses, evaluated by the site managers and then readjusted (geometry, colour and brightness) for better compliance.

In the end, the result is an augmented reality application with co-lighting, on which the scenery can be visualized under different light atmospheres (rainy, overcast and sunny, artificial with a candle) in accordance with the reality of the site, and which is currently used on site. The appearance model used, although chosen for its physical plausibility, is often insufficient in relation to the expectations and thus requires manual adjustments. The visual perception of such a historical artefact, currently absent from the rendering pipeline, remains to be considered.

### KEYWORDS

heritage building | mural decorations | augmented reality | appearance rendering | co-lighting



## The Walls of the City: A living text from the Chilean social revolution in Valdivia-in color

Elisa Cordero-Jahr<sup>a\*</sup>, Malena Samaniego-Salinas<sup>b\*</sup>,  
Irene Alvear-Azcárate

<sup>a</sup>Design School, Architecture and Arts Faculty, Universidad Austral de Chile

<sup>b</sup>Institute for Linguistics Literature, Philosophy and Humanities Faculty, Universidad Austral de Chile

\*Corresponding author: [elisacordero@uach.cl](mailto:elisacordero@uach.cl)

On October 18, 2019, following an incident involving high school students in the Santiago subway, Chile witnessed what is now commonly referred to as the social ‘shattering’ or ‘awakening’. After decades of living under the profound injustice and inequality stemming from the prevailing neoliberal economic model, Chileans rose up in mass and began protesting under the slogan «Chile woke up.»

People from all ages and walks of life joined students in both peaceful and violent protest, demanding basic rights such as public education, quality healthcare for all, and decent pensions, as well as equal rights for women and minorities.

In these massive street gatherings, the absence of potentially divisive speeches suddenly became evident. Words, however, were not gone; they soon plagued the walls of Chile’s cities bringing them to life. The city became a living document, a list of demands inscribed by the public in various formats: graffiti, murals, stickers, stencils. May color be associated to specific demands and social groups? What are the spatial changes triggered by the appearance of these colorful slogans? What is the relationship between the content of the written text and the color? How are demands re-textualized in this collective, asynchronous and ephemeral articulation of grievances? What messages and colors remain and predominate? What is the effect of these claims and colors emblazoned all over the city on its inhabitants? Does color carry symbolic meaning in these graffitiies?

Based on direct observation, a longitudinal registry, and interviews, the authors attempt to answer these and other questions, while the social outbreak continues amidst the COVID 19 crisis.

### KEYWORDS

color | city | street | social outbreak

## An application of hyper-spectral color technique in finding proper color pigment for painting conservation

M. James Shyu<sup>a\*</sup>, Yuan-Feng Chang<sup>b\*</sup>

<sup>a</sup>Chinese Culture University, Taipei, Taiwan

<sup>b</sup>National Taiwan Normal University, Taipei, Taiwan

\*Corresponding author: mjshyu@faculty.pccu.edu.tw

In the color compensation process for painting restoration and conservation, the missing or broken section is usually mended by using an infill of new materials. From the conservation science point of view, this retouched work should restore the original appearance of the artifact, yet be traceable in the future for identifying the newly added materials. From the color science point of view, the color appearance between the original and retouched materials should present minimum color difference in the visible spectrum, nevertheless the difference between these materials still can be distinguished after a certain process for conservation purpose. This study utilizes hyper-spectral color technique to help conservators in finding the proper color pigment for restoration processes while still accommodating the above considerations.

Two kinds of color pigments commonly used in Asian glue painting are the primary objects in this study. One kind is traditional mineral pigments found in the natural world. Another kind is artificial pigments. Color swatch samples for both kinds of pigments were prepared in a way such that artists would usually use them in Asian glue painting. Several layers were applied for each pigment sample to assure the evenness of color. A calibrated hyper-spectral imaging system was used to gather the spectral information for the pigment samples. The spectral reflectance values of the samples were gathered in both visible and near-infrared (NIR) bands at 400 – 1000 nm.

In order to achieve the goal of finding a visually similar color material to fill the restored area and yet to preserve the identity, the colorimetric value is used as the index for similarity in the visible spectrum and the narrow-band spectral reflectance difference in the near-infrared region is used to reveal the difference. The CIELAB values are calculated from the spectral reflectance values to serve as the index for similarity in the visible region. Moreover, for the near infrared region, the difference of the spectral reflectance values or narrow-band NIR image is used to distinguish the restored materials from the original. The results indicate that the combination of colorimetric and spectral reflectance values in and beyond visible bands can be a useful index for this purpose. This can be a good example for the reason to study color processes going beyond colorimetric approaches into the spectral domain.

### KEYWORDS

*heritage science, painting conservation, non-invasive analysis, spectral color, hyper-spectral color imaging*

## SESSIONS 5 & 6

# PERCEPTION, CAPTATION AND COLOUR CREATION

### SESSION 5

**Scientific Dimension and economical impact Human, animal and machine Vision ; economic impacts ; design, marketing, packaging...**

Part 1 022 029 035 039 048

Part 2 016 068 095 101 114

### SESSION 6

**Social and cultural extents, New kind of knowledge and cultural dissemination (sound and light show, digital devices and human interaction), artwork reproduction, new fields of creation and digital colour fidelity to natural colours, ethics and virtual or real artwork restoration, virtual/real make-up, etc.**

051 066 080 105 130

## The meaning of colors in Brazilian food packaging

Carla Pereira

Universidade Federal de Campina Grande, Paraíba, Brazil  
Corresponding author: carlapereira.ufcg@gmail.com

In the context of the diversity and complexity of contemporary genre production, food packaging not only informs biological characteristics of products. They also need to communicate intangible qualities of food, linked to the satisfaction of psychological, emotional and cultural needs of consumers. For this, design builds increasingly complex discourses and uses multimodal texts to enable self-sufficient communication to products. Associating verbal and visual language, packaging communicates through the plastic elements of design, such as shapes, textures and colors.

This paper discusses the system of color meanings in the context of Brazilian food packaging. This research aims to explain the structure of this system and demonstrate that the color of packaging design reflects ideological and cultural conceptions that take place in contemporary society.

Therefore, an empirical study was conducted, with a qualitative approach, in which the colors of 612 food packages (including food and non-alcoholic beverages) sold in supermarkets in the city of São Paulo, Brazil, were analyzed. The analysis tools used come from semiology/semiotics. Based on Saussure's theory, the language of colors was investigated as a sign system, whose structure is formed by identity, association, differentiation and opposition relations between its elements. The study was also based on classification and analysis models proposed by Peirce and Groupe  $\mu$ . From the analysis model elaborated by Groupe  $\mu$ , the colors were considered as plastic signs, in which hue, lightness and chroma constitute significant units. From Peirce's theory of sign, the chromatic signs were categorized by similarity, connection or convention.

In the corpus analyzed, the colors performed three semiotic functions: (1) to show the food color (iconic function), (2) to signal objective characteristics of food products (indicative function), and (3) to represent psychological and cultural qualities (symbolic function). It was verified that the system of color meanings in the food packaging is organized from the color attributes (hue, lightness and chroma) and from chromatic oppositions. Different hues corresponded to different meanings – this basic principle particularizes the varieties of products and brands. On the other hand, differences in lightness and chroma corresponded to differences in meaning mainly linked to the food products image. Concepts seen as opposites in the food system were represented in the design by opposite chromatic characteristics: cold hues for 'health' and warm hues for 'pleasure', low chroma for the 'natural' and high chroma for the 'artificial', the achromatic for the 'refined' and the colored for the 'common'.

Finally, this research found that the most frequent symbolic meanings of colors in Brazilian food packaging correspond to the different discourses that guide contemporary dietary practices. It is concluded that the packaging colors reflect the heterogeneity of the consumption groups – such as white for the 'healthy', black for the 'refined', pink for 'women', green for the 'ecological' – and, in this sense, function as markers of Identity.

### KEYWORDS

color symbolism | food packaging | semiotics

## Visual perception of natural colours in paintings: an eye-tracking study of Grünewald's *Resurrection*

Pablo Fontoura<sup>abc\*</sup>, Michel Menu<sup>b</sup>,  
Jean-Marie Schaeffer<sup>ac</sup>

<sup>a</sup>Ecole des Hautes Etudes en Sciences Sociales (EHESS), Paris, France.

<sup>b</sup>C2RMF, Centre de Recherche et de Restauration des Musées de France (C2RMF), Paris, France.

<sup>c</sup>Paris Sciences et Lettres, PSL Research University, Paris, France.

<sup>d</sup>Chimie-ParisTech, Institut de Recherche de Chimie-Paris (IRCP), Paris, France

\*Corresponding author: pablo.silveiradafontoura@ehess.fr

long been approached from multiple perspectives: its social and anthropological meaning (Pastoureau), its cultural history (Gage), and its semiotic reading (Roque). At the same time, philosophers and scientists have studied the effects of colours on people from a subjective to an objective standpoint (Helmholtz; Le Grand; Zeki). But even though research in art history that uses multidisciplinary scientific approaches to investigate visual perception in art is increasing (Rosenberg; Lanthony), few have focused on the influence of natural colours on the visual behavior of people looking at paintings, and especially on how it affects their overall visual experience.

In order to address the question of how observers look at natural colours perceived directly from original paintings, we aim to present an extract of a broader eye-tracking study we performed on the remarkable German Renaissance Isenheim Altarpiece (1512-1516) by Matthias Grünewald, kept at the Unterlinden Museum in Colmar, France. We invited 52 participants from different backgrounds to freely look at the altarpiece wearing eye-tracking glasses, which recorded the exact position and time people spent on each part of the canvases. Participants also commented on their visual observations, and the transcription of their interviews were treated using text mining and qualitative discourse analysis techniques.

This article is focused on one panel of the Isenheim *Altarpiece*: the *Resurrection*. This specific painting is widely recognized for the qualities of its pictorial representation. At the same time, it has a historical and a transcendent content that enhances the complexity of the potential meanings of its colours palette and the effects it provokes on observers, which makes of the *Resurrection* a suitable case study of natural colours perception.

Eye-tracking results indicate that participants perform greater fixation count and longer fixation time on yellow and brown; and shorter fixation count and time on orange, green, and black. Contrastingly, orange, red, green, and blue are the elements people look at first, while brown, grey, and yellow are perceived at last. This indicates that the colours that are more attractive initially do not necessarily hold people's attention over time. The eyes of the observers visit yellow and brown zones almost three times more often than orange, green, and black ones. On the other hand, the number of saccades on yellow, but also on brown, are notably higher, suggesting those colours work not only as attention triggers, but as resting areas for the eyes in between longer fixations in other zones. Finally, saccade amplitude suggests that people tend to perform a detailed visual exploration of the painting over a broader exploration of the elements represented within.

Qualitative interviews revealed that visitors identify and appreciate contrasts and gradients, and relate their perception mostly to light. When participants talk directly about colours, they mention yellow, blue, red, and white, and associate them with calmness, abundance, comfort, joy, movement, and metamorphosis. This suggests that the colours of the *Resurrection* are charged with transcendent meaning, and they explicitly contribute to the contemporary understanding and interpretation of the image.

Future investigation of the relations of eye-tracking data and of the qualitative aspects of people's perception of colours of the *Resurrection*, associated with other scientific imagery analysis, can contribute to a broader understanding of the effects of material aspects of paintings on people, and on the way art historians interpret such images over time.

### KEYWORDS

eye tracking | colors | paintings | visual perception | Matthias Grünewald

## Long-term adaptation to color filters in anomalous trichromats

John S. Werner<sup>a\*</sup>, Brennan Marsh-Armstrong<sup>a</sup>,  
Kenneth R. Knoblauch<sup>bc</sup>

<sup>a</sup>University of California, Davis

<sup>b</sup>Université Lyon, Claude Bernard 1

<sup>c</sup>University of South-Eastern Norway, Kongsberg

\*Corresponding author: jswerner@ucdavis.edu

Spectrally selective filters have been proposed for more than a century in an attempt to modify the spectral distribution of light reaching the retina in order improve color discrimination of observers with color vision deficiencies. Here, we tested sex-linked, anomalous trichromats, the most common form of congenital color vision deficiency, affecting ~6% of Caucasian males and <1% of females. Commonly proposed broad-band filters may modify the illuminant to defeat standardized tests, but to create robust differential stimulation of middle- (M-) and long-wave (L-) cone signals in anomalous trichromats, a notch filter is needed. We tested a notch filter (Enchroma) designed for this purpose. Maximum Likelihood Difference Scaling (MLDS) was used to estimate suprathreshold contrast response functions for Gabor patterns (1 c/deg, 4 deg diameter envelope) modulated along luminance or L-M color directions. Baseline data from normal, protanomalous, and deuteranomalous observers using this technique are described elsewhere. Based on a signal detection model, perceptual scale values (parameterized as  $d'$ ) were fitted by a Michaelis-Menten function so that response maxima and contrast gain parameters could be estimated for each subject. Among these observers, 2 protanomalous and 5 deuteranomalous observers were tested following at least 60 prior tests conducted over three two-hour sessions that established a stable baseline that was confirmed on day one of this experiment. Subjects then wore the test glasses for approximately two weeks and were tested on days 2, 4 and 11. All subject testing was performed without the glasses. For all subjects there was no change in response gain along the luminance axis. Increases in response gain along the L-M axis occurred with increasing usage of the filters. We quantified performance in terms of the ratio of L-M to luminance response gain and found that the ratio for anomalous observers after wearing the Enchroma glasses approached the value of normal trichromats. On average, the difference in this ratio between anomalous and normal trichromats was decreased by 50% by day 9. Another protanomalous observer wore neutral density filters and was tested on the same schedule as the test group. He showed no change in response gain at any time point for either axis of stimulus modulation. In addition, two normal trichromats were tested with Enchroma glasses but showed no changes in response gain over the same time course. Taken together, these findings indicate that increases in LM response over time with the Enchroma glasses must be attributed to something other than practice effects, possibly perceptual learning because the gains persisted when the filters were not worn.

### KEYWORDS

color vision deficiency | color filters

## Experimental determination of relevant colors that describe the color palette of paintings

J.L. Nieves<sup>a\*</sup>, Luis Gomez Robledo<sup>a</sup>, Javier Romero<sup>a</sup>

<sup>a</sup>University of Granada, Granada, Spain  
\*Corresponding author: jnieves@ugr.es

In a previous work [Nieves et al. Appl.Opt. 59, 1732-1740 (2020)] we heuristically introduced the so-called “relevant colors” in a painting to describe the number of colors that would stand out for an observer when just glancing at a painting. These relevant colors would characterize the color palette of a scene as being obtained on the basis of the discernible colors that were colorimetrically different within the scene. We computationally obtained a number of 18 relevant colors on average, which were representative on average of the color content of every image.

The purpose of this work is to check if that computation agrees with an experimental determination (i.e. by means of a psychophysical estimation) of relevant colors describing a painting. To do so, a set of image paintings is presented to different observers who has to find the set of colors that better describe each painting. In each trial of the experiment the observer is instructed to mark with the mouse every pixel within the image that contains a relevant color. But, what does relevant color mean? Observers visually scan the whole painting and are asked to select those pixels belonging to a relevant chromatic area. It is not a color categorization experiment and thus observers are free to select as many colors as they prefer. There is no time limitation per painting to finish the task although no more than 60 s per image is recommend to avoid visual fatigue. Two different set of images are selected: 20 paintings belonging to the Prado museum (<https://www.museodelprado.es/en/the-collection>), which are characterized by a complex spatio-chromatic content, and 20 images from the public database of Khan et al. (<http://www.cat.uab.cat/~joost/painting91.html>), which are categorized as simple abstract paintings and/or not containing complex spatio-chromatic content.

Preliminary results suggest that there is almost no difference between the number of subjective colors obtained for the Prado museum's set (21 colors with  $\pm 5$  standard deviation) and the Khan's set (22  $\pm 11$  colors). Those numbers are also in close agreement with the computational number of relevant colors if we apply the previous algorithm to those paintings (19  $\pm 6$  relevant colors). Nevertheless, there is no full agreement between the CIE Lab set of colors selected in the psychophysical experiment and the automatic relevant colors selected by the computational algorithm. It seems that depending on the painting the constraints imposed by the algorithm are too restrictive and should be relaxed and optimized somehow. Future results would contain further analysis of the possible implications of those differences in the segmentation of the color paintings.

### KEYWORDS

color perception | color preference | color imaging

## Perception and Evaluation of Luminous Colour Differences

Karin Bieske, Christoph Schierz, Nicole Stubenrauch

Technische Universität Ilmenau, Ilmenau, Germany  
Corresponding author: Karin.Bieske@TU-Ilmenau.de

With the introduction of LED technology to lighting applications, new concepts have emerged for luminaires. To produce light sources with enough luminous flux, several LEDs are typically built into one luminaire. Manufacturing tolerances, thermal influences and different ageing processes can vary from LED to LED. This can lead to differences in luminous colour and to disturbing colour inhomogeneities within a luminaire and between adjacent luminaires. The binning of LEDs is a method to group LEDs into classes to ensure that only LEDs with similar luminous colour are built into a single luminaire. To define colour tolerance limits, knowledge of the perception of luminous colour differences and their exact prediction is required.

The description of luminous colours is based on tristimulus values and values derived from them (e.g. chromaticity coordinates). The MacAdam ellipses are typically the reference when luminous colour differences are evaluated. The calculations and the colorimetry of the tristimulus values are based on the colour matching functions (CMFs) for the CIE standard observer of 1931 (CIE 1931). Metameric colour stimuli are spectrally different but have identical tristimulus values. In theory, they should not be visually distinguishable.

However, studies have shown that differences are perceived when people compare metameric luminous colours visually. Despite the fact that identical tristimulus values had been measured, subjects have recognized clear differences in luminous colours. Investigations involving a variety of spectral distributions (10 types of COB LEDs with differences in the spectral distributions due to production process), object sizes (viewing angle of 2° and 10°) and observation conditions (surrounding with CCT: 2700 K/ 3500°K/ 6500 K and without light) were carried out with subjects (N = 119) of different age groups (young vs. old). Not only the standard CMFs, but additional CMFs were tested for their reliability in modelling metameric colour perception. The test setup consisted of two adjacent lightboxes with diffusors (mean luminance of both: 800 cd/m<sup>2</sup>) in an illuminated environment (mean luminance: 200 cd/m<sup>2</sup>). Luminous colour differences between the test fields were calculated based on colorimetry and subjects evaluated these under identical viewing conditions. The data were analysed by linear regression of the subjective ratings versus calculated colour differences for each CMF's.

The results show that differences in luminous colour perception are attributed particularly to spectral differences in the short-wave spectral range. The luminous colours of the environment to which the eye adapts chromatically do indeed influence the perceived colour of the different objects compared. In contrast, there is no impact of the luminous colours of the environment on the colour difference seen between the different test objects (The cones are similarly adapted in both test fields.). All CMFs which have been investigated so far reveal systematic deviations in how they predict the perception of colour differences. Colour perception is influenced by age-related changes of the eye. This must be taken into account when luminous colour differences are being described. For young persons (< 35 years), colour perception is best described on the basis of the CMFs proposed by POLSTER. For older persons (> 60 years), the luminous colour differences which best correlate with the subjects' judgements are those calculated with the standard CMFs CIE 1931, the age-corrected CMFs (CIE 170-1: 2006) as well as the age-corrected CMFs proposed by POLSTER. The investigations show a stronger influence by age than by observer field size.

### KEYWORDS

perception | luminous colour differences | colour-matching functions



## A general colour selection approach modelling by new research data of designers

Yun Chen<sup>a</sup>, Jianan Zhao<sup>b\*</sup>, Stephen Westland<sup>a</sup>

<sup>a</sup>University of Leeds, Leeds, United Kingdom

<sup>b</sup>Shanghai Jiao Tong University, Shanghai, China

\*Corresponding author: jzhao2@cca.edu

Although many design process studies and design theories were presented, in reality, designers have rarely followed standard rules (Bengtsson, 2013:89). A design process is a form of personal self-expression. The type of approach that designers use in their design work depends on their preference, experience and education background (Muratovski, 2015:2-3). Therefore, this work focused on the design process and colour selection understanding by collecting new research data from the designers and gathering the ideas from their design process to summarise a general colour selection method.

This work employs a semi-structured interview approach in a one-to-one interview format to investigate the process of design and collect their colour selection method. A total of twenty designers were interviewed from different design areas, working experience, age groups, cultural background and workplace around Korea, China, South Africa, Mexico and the United Kingdom. Ground Theory method and TF-IDF data analysis method were carried out in interview data analysis. A three-step approach was summarised in this study. Besides, several characteristics during the design and colour selection process were presented.

### KEYWORDS

colour choosing | design process | designer | approach

## The colour of emerging textile for urban regeneration

Katia Gasparinia<sup>a\*</sup>

<sup>a</sup>IUAV University of Venice, Venice (Italy)

\*Corresponding author: [katia.gasparini@iuav.it](mailto:katia.gasparini@iuav.it)

In the contemporary Age the urban scene changes appearance and space perception through innovative design approaches: new shapes and paths, interactive installations, connected spaces and so on.

Some of the most famous projects of urban design in the World, where the colour plays a key role are, for example: the historical project in Rotterdam of Topotek 1 called “Superkilen”; some projects of Martha Schwartz Architect; the Red Ribbon Park in China; the Millenium Park in Chicago; several projects of the Serpentine Gallery Pavillions, and many others. In these installations the colour and light became the most important design tool, especially in the experimental projects designed by some young architects and designers using emerging technologies and coloured effects.

In fact, within some urban spaces around the World, in some cases we can report of interesting innovative pavilions or urban spaces covered through fluid, dynamic and coloured shapes that attract people attention, as landmarks.

Some of the most interesting installations are made by parametric design and emerging materials as passive and active smart textile, emerging technologies, as 3D printing and digital technologies.

Usually, the installation's design is conceived with textile materials, they're made thanks to the cooperation of creative designer with lighting and digital engineer companies, in a multidisciplinary approach.

Indeed, Jenny Sabin's installation at Moma PS2, called Lumen (2017) or Janet Echelman coloured sculptures in Vancouver (2014) are famous. The common features of these two installations are: the use of digital technologies; the interaction with people; the use of innovative fabric; the changing colours thanks to the light effect; the parametric design concept.

These urban installations look like moving sculptures, being 3D interactive textile that changes the urban space and colours.

The paper will report to assess the progress of ongoing research about these emerging textiles. The research methodology is based on the analysis of international case studies of interactive coloured installations in urban space and their impact on the environment, in particular when designed with digital design technologies (parametric design?), conceived as a dynamic system, and a set of other criteria.

The aim of this research is to define the guideline for designers, architects and urban planners interested at innovative approach to urban regeneration design. The colour is the most important design tools for a Human Centred Design in urban scene: it's important for people way-finding and the space regeneration. The emerging technologies in this context are fundamental for connecting the project to the citizen.

### KEYWORDS

*emerging technologies | urban design | colour*

## Color analysis of the Old Town district in Cracow

Agata Kwiatkowska-Lubańska<sup>a</sup>, Marta Osipczuk<sup>b</sup>

<sup>a</sup>Jan Matejko Academy of Fine Arts in Cracow

<sup>b</sup>Jan Matejko Academy of Fine Arts in Cracow

Krakow is a significant city for Polish culture, the historic centre (the Old Town district) attracts over 15 million tourists every year. The Old Town district is largely under conservation protection, but strict colouring recommendations exist only for the part of the buildings situated between the Main Market Square and the line of the former city walls. In the rest of the district, the colours are chosen in a chaotic way, not taking into account the importance of colour for the image of the city.

In the academic year 2019/2020, a group of 30 second-year students of the Academy of Fine Arts in Krakow, under the direction of the lecturers, analysed the colour schemes of 300 buildings in the Old Town district. The analysis made use of Jean-Philippe Lenclos' method of colour geography, taking into account in situ colour samples, the use of NCS colour charts and photographic documentation.

A separate colour palette was created for each of the buildings, taking into account the colours of the facade, windows and doors, as well as the notation of the colours in the NCS system. On this basis, a colour map of the Old Town district was created, which was analysed for such features as hue, chromaticness, whiteness and blackness. As a result of the analysis, conclusions concerning the local colour palette were formulated, which is to be followed by the creation of a colour chart dedicated to the architecture of Krakow.

### KEYWORDS

*environmental colour | colour and heritage | colour in education*

## A new method for researching the chromatic identity of architectural ensembles

Bárbara Silva<sup>a\*</sup>, João Pernão<sup>a</sup>

<sup>a</sup>CIAUD, Lisbon School of Architecture; Universidade de Lisboa, Lisbon, Portugal

\*Corresponding author: [barbaramsilva@campus.ul.pt](mailto:barbaramsilva@campus.ul.pt)

Until the industrial revolution, materials and coating techniques depended and expressed the culture of regional construction through its geographic and geological context: a «Geography of Colour» existed. From the 20<sup>th</sup> century, that condition changed: many countries in the world became aware of the impact caused by chromatic alterations in architectural ensembles, especially in environments and landscapes with heritage value, due to the endless possibilities of chemically synthesized pigments that de-characterise its regional context. Since then, several studies have been conducted on the investigation of the chromatic identity of buildings and sites, in order to restore their authenticity and formulate colour plans, recommendations and guidelines for chromatic interventions of renovation, conservation and restoration.

This paper aims to present a method for data collection created to study the chromatic identity of architectural ensembles, based on the recognition of the variables that compose this identity. It will be demonstrated its application on the historic centre of Tiradentes, Minas Gerais, Brazil, where it was implemented with the main purpose to enable the documentation of relevant information on the object of study. The paper will be presented according to the following phases of study: (i) description of the process of construction of the method, explaining how the variables were identified; (ii) attribution of categories for variables characterisation, describing the method's development process by using the variables identified; and (iii) validation and results of the method, reporting its application in field research, emphasizing the challenges and advantages observed in its implementation.

The results of this study demonstrated that the proposed method is valid since its applicability has been proven, as well as its capacity to achieve its main purpose. In addition to being easily replicated and adapted in future studies, it introduces new possibilities for data analysis and can be used to guide or complement other usual data collection methods in the field of research, such as historical research, direct observation, exploratory interviews and archaeological methods. Among the conclusions, it was emphasized the need for future studies that demonstrate the impacts of its implementation on achieving further results on the data analysis. Finally, it was confirmed the innovative character of the proposed method and it was highlighted that innovation is important and necessary for the knowledge and preservation of tradition.

### KEYWORDS

chromatic identity | data collection | method | architecture | heritage conservation

## Lingua Colour – an open colour system for the graphic arts

Craig Kirkwood

Cardiff Metropolitan University, Wales

In the English-speaking world, and in many countries beyond, colour discourse in the graphic arts and design professions continues to be dominated by the Pantone Matching System. While this privately-owned, proprietary system was effective in the years prior to digital ‘desktop’ publishing it is no longer adequate for several key reasons.

Firstly, it was designed at a time when pre-mixed ‘spot’ colours were a popular form of printing, whereas today, most printing is done on either four-colour, offset lithography systems or on short-run, digital printers based on inkjet, laser or dye-sublimation technology. And of course, we are now in a world where the vast majority of information is not printed at all but is delivered to monitors and devices held in our hands, on our laps, or on our dashboards.

I am proposing the development of a new system, better suited to today’s world of screens, devices and mixed printing systems that are largely opaque to most users. Such a system should be open, educational, affordable and flexible for use across any number of creative domains. Lingua Colour is the working title of the proposed system and its development is informed by two lines of enquiry.

The first is to determine the level of colour competency and literacy in the creative community: could most designers differentiate between additive and subtractive colour spaces? Could they confidently ensure colour consistency from screen to print? Or anticipate the result of projecting blue light onto a (normally) red object? From my experience as a teacher and software instructor I can attest that few designers could do any of these relatively basic tasks. To quantify my experience, I am conducting a colour competency survey, the preliminary results of which will be presented at the AIC conference.

The second line of enquiry relates to the most effective way of delivering a colour system for our times. Should we try to enhance the colour ‘fan guide’ model used by Pantone, NCS and RAL? Or perhaps the booklets of colour swatches used by paint companies? Or can we adopt the colour ‘atlas’ or the ‘tree’ of the Munsell System? Or is there an entirely new way of conveying colour to designers, students and creatives that recognises the relative volume of screen-delivered content vs. that of print and physical media?

It would be foolish to dismiss the contribution of any of these approaches and yet this is also an opportunity to disrupt the way in which we use, teach and understand colour. I am developing several digital and physical prototypes that will be tested by focus groups to determine their efficacy as both a professional and educational tool in the use and management of colour. The results of these two lines of enquiry will inform the development of the Lingua Colour system.

### KEYWORDS

colour management | colour systems | education | graphic design

## Analysis of mechanism in material estimation by CNN

Nozomi Tobaru<sup>a</sup>, Noriko Yata<sup>a</sup>, Yoshitsugu Manabe<sup>a</sup>

<sup>a</sup>Chiba University, Japan

\*Corresponding author: tobaru90226@chiba-u.jp

Humans can perceive texture from the physical properties of the surface of an object. Texture is a perception caused by differences in the properties of materials, which also affect the appearance of color. However, it is still unclear how humans process vision and from what features they infer materials. On the other hand, the CNN (Convolutional Neural Network), a model that imitates the hierarchical information processing process in the brain, has been used to study vision. The purpose of this study is to analyze the material estimation mechanism in material estimation CNNs. We propose a method to construct a relationship between intermediate features and materials in material estimation CNNs using evolutionary computation and to analyze the importance of intermediate features in a particular texture.

First, to analyze the material estimation mechanism, we construct the CNNs learned in the material estimation task. The architecture is based on models such as VGG16, and the material recognition dataset is based on the MINC-2500 (Materials in Context Database) published by Bell et al. In order to learn efficiently even with a small dataset, we construct a CNN that can handle the material estimation task by fine-tuning of ImageNet. As a result, highly accurate material estimation was achieved.

Next, to analyze the relationship between the intermediate features and the materials in the constructed CNN, we construct a formula by evolutionary calculations. In this study, we use CNN features as the activation values for each layer when images are input to CNN, input CNN features for any layer, and create training data using specific materials as the output. Using these training data, we formulate the objective variables by optimizing the combinations of arithmetic nodes and constructing a network that realizes input-output relations that match the training data, using CGP (Cartesian Genetic Programming) which is a type of evolutionary computation. Since the number of parameters for CNN features is too large to be calculated by CGP, the parameters are selected by analyzing important features for each texture using the gradient information.

As a result of the experiment, it was confirmed that a material estimation CNN could be constructed even with a small data set by transfer learning. Many of the mistakes were made, for example, in images with various materials, so we believe that we have obtained a CNN worthy of analysis of the mechanism. We also confirmed that the relationship between CNN features and specific textures could be constructed using CGP.

### KEYWORDS

*convolutional neural network | evolutionary computation | material estimation*

## Effect-coating glint according to binocular and monocular vision

Min-Ho Jung<sup>a\*</sup>, Jean Baptiste Thomas<sup>a</sup>,  
Marius Pedersen<sup>a</sup>, Vien Cheung<sup>b</sup>, Peter A. Rhodes<sup>b</sup>

<sup>a</sup>Norwegian University of Science and Technology, Gjøvik, Norway

<sup>b</sup>University of Leeds, Leeds, United Kingdom

\*Corresponding author: colourjung@gmail.com

Over the past few decades, the texture of visible pigment particles, known as glint, has been one of the most important features for attracting customers in the automobile industry. Therefore, quantifying the effect of glint has become essential for product development and quality control. Although research-led understanding of glint has been expanded gradually, there is only limited information about how glint is influenced by viewing conditions and material properties.

We investigate the impact of viewing mode in glint perception for physical samples. The first aim of this study is to verify how perceptual glint is influenced by binocular and monocular vision. This result could be applied to aid the reproduction of glint on two kinds of displays: 2D based on monocular vision and 3D based on binocular (stereoscopic) vision. In practice, most research for glint has been performed under binocular vision, but many people are also used to seeing images of glinting products on a 2D monitor or in print. There is a lack of research about the reproduction of glint in 2D. The second aim is to identify the difference in glint perception between two kinds of surface finishing, rough and smooth. Each sample used in the experiment was specially designed so that half of it is rough and another half smooth while maintaining the same glint level across the entire surface. Although the majority of earlier research has been focused on effect coatings according to only external factors such as the illumination and viewing conditions, this study attempted to verify the effect of glint according to the internal conditions of samples due to the different type of surface and under the same viewing conditions.

Fifteen observers with normal visual acuity and colour vision will participate in the psychophysical experiment. Each participant will scale the perceptual glint of 11 grey effect-coating panels by comparison with a reference sample using monocular vision. After assessing the glint on two kinds of surface using the same vision, they will then have another session on same task using stereoscopic vision. This session is carried out twice. In total, 880 observations (11 samples × 2 viewing modes × 2 repeats × 20 observers) are to be obtained in the experiment. An initial viewing geometry of 15°/0° is provided, but observers are free to move the tilting table on which samples are mounted while assessing glint. The initial viewing condition is recommended by ASTM as one of several angles for the measurement of interference pigments. A set of samples consisting of 11 different physical sizes of coarse flakes is provided, having an approximate diameter of between 9 to 650 μm.

The conclusion is anticipated from limited results. We can be more specific: Binocular vision helps to reduce the variance between observers, so improve the performance on glint judgement. The perception of glint is affected by the surface finishing of the sample. The glint on a smooth finishing is perceptually emphasized and ignored within the range of highest and lowest glint respectively more so than that on rough finishings, regardless of the mode of viewing.

### KEYWORDS

glint | monocular vision | binocular vision

## Cultural probe into colour preferences for home interiors amongst Indian youth

Deepshikha<sup>a\*</sup>

<sup>a</sup>Independent Researcher

\*Corresponding author: dee.shikhajha@gmail.com

India has varied cross-cultural preferences for clothing, home interior and accessories. The reason being, it cherishes her lengthy and rich traditions and appreciates the global trends – accepting or merging them with existing styles. The first objective of the paper presents a brief study on color preferences of young population for home interiors in India – the existing color palette and a palette they would choose if they had the choice, because it is usually the elders of the family who decide color options for painting home interiors. The color palette for this study was derived from a visual cultural survey of over 200 internet images curated from cultural elements of different states of India summarized and represented through 88 colors for the purpose of the user study. Color preferences for living room, dining area, bedroom and kitchen have been represented through word count and categorization.

Naturally colored home interiors, exterior, floor or ceiling are common in rural and rural-urban areas in India. The second objective of the paper enquires from the young population whether they would use naturally made colors, if they were commercially available for painting their homes, even if it were a bit expensive than the easily available chemical ones. The color palette was derived by working with natural materials and creating small color chip samples for the purpose of the study. The naturally made colors were however not scientifically tested for commercial application, but prepared only for the user study. It was found that young population was readily willing to use naturally made colors if available for painting home interior/exterior as it made them feel that they ‘cared for nature and its resources’ and ‘were taking a small yet significant step towards sustainable development’. The first two studies were carried out with 55 young respondents (30 male and 25 female) studying in a national technical institution located in central part India within the age group of 18-30 years.

The third objective of the paper analyses the response of 20 young respondents (students and working professionals) about artificial lighting set-up inside home interiors. The result demonstrates that changing light and colors during day and night hours through a bulb or similar electric light can only be used occasionally, such as during festivals, celebrations, etc. It makes the ambience ‘artificial’ and feels ‘good’ only temporarily for a specific purpose. Otherwise the wall colors and contemporary lighting makes them more comfortable for longer periods than dramatic/artificial light effects created by innovative lighting.

The present paper is a preliminary study to probe further into color preferences of youth not only for home interiors, but also, office, libraries, museums and art galleries, as lighting in each scenario is decided differently for a significant trend report. India being a culturally distinct population needs in-depth statistical studies with larger samples for comparison between the above-mentioned scenarios in further stages.

### KEYWORDS

*home interiors | colour preferences | cultural influences*



## Yērāqôn, a natural colour: ‘the colour of the fear’ (Jer 30.6)

Lourdes García Ureña

University CEU – San Pablo, Madrid (Spain)  
Corresponding author: lgarciau@ceu.es

Although in the Hebrew Bible a specific term does not appear to refer to ‘colour’, unlike what happens in its Greek and Latin versions, colour terms are used in the different books that compose it denoting the various chromatic spectrum that the nature shows. In the Semitic world colour is what is perceived on the objects and human beings through the sight thanks the presence of light. By this reason, the study of colour in the Bible goes intrinsically joined to the study of the entity imbued by colour. In the most of the cases the modern reader can know the tonality expressed by colour terms precisely through the mentioned entity. Indeed, sometimes, the own objects of the nature are used to denote colour as it happens with the precious stones, the metals or the cloths.

In the Book of Consolation the prophet Jeremiah uses the nominal lexeme yērāqôn to describe the faces of the soldiers terrified before the attack of the enemy (Jer 30.6). It is a peculiar use because yērāqôn appears 5 times in the Hebrew Bible joined to šidāpôn, ‘blight’, with the meaning of ‘mildew’ (Deut 28.22; 1 Kings 8.37; Jer 30.6; Amos 4.9; Hag. 2.17; 2 Chr. 6.28). In fact, the main dictionaries and studies about colour propose that yērāqôn has two different meanings: achromatic that is the most frequent (mildew) and the other one chromatic (paleness). Nevertheless, neither Greek neither Latin version, having colour terms that could be equivalents, use them and instead they resort to a term expressing a skin disease characterized by the fact that the person acquires a yellow hue as happens with mold: ἰκτερός ‘jaundice’ and aurugo ‘jaundice’. Thus, it is logical asking if yērāqôn denotes effectiveness ‘paleness’.

As it is mentioned, Jeremiah utilizes yērāqôn to describe the soldiers’ faces (Jer 30.6). As today, in Israel, the face reflects the emotions that the human being experiences, through gestures or a colour change on the face, as it can naturally turn red or pale. As it is known, one of the fear effects is the unexpected paleness. So it stands to set out that yērāqôn does indeed mean paleness. However, how can we explain the origin of this new meaning? Jer 30.6 appears in the context of divine punishment as occurs when it has the meaning of mildew. The mildew, attacking the plants, discolours them and they acquired a hue of low saturation between green and yellow. It seems that Jeremiah pays attention in the colour of the plants and, through a cognitive metonymy of kind ENTITY and SALIENT PROPERTY, uses yērāqôn to express only the colour acquired by a person, not ill as the plants, but terrified by fear. This explains that yērāqôn does not denote a plant illness, but the colour of fear.

### KEYWORDS

colour | emotion | paleness | fear | Bible

## Blue-blocking lenses – how much short wavelength light can be removed from daylight illuminants without significantly affecting colour vision?

John L Barbur<sup>a\*</sup>, Benjamin EW Evans<sup>a</sup>,  
Elisabetta Baldanzi<sup>b</sup>, Regina Comparetto<sup>b</sup>,  
Alessia Fava<sup>b</sup>, Alessandro Farini<sup>b</sup>

<sup>a</sup>Applied Vision Research Centre, School of Health Sciences, Northampton Square, City, University of London, UK

<sup>b</sup>CNR-Istituto Nazionale di Ottica, Largo Enrico Fermi 6 50125 Firenze, Italy

\*Corresponding author: j.l.barbur@city.ac.uk

Rods and S-cones respond best to short-wavelength light. Signals from rods feed directly into specialised, intrinsically photosensitive ganglion cells (ipRGCs) which contain melanopsin, a newly discovered visual pigment within the ganglion cell body. Melanopsin responds best to short wavelength light and signals from these cells in the retina are channeled to the midbrain nuclei involved in the control of circadian rhythms and other non-visual functions. High-intensity, blue light can enhance alertness and the use of blue-enhanced illuminants has been suggested as a possible treatment for daytime sleepiness. Blue-rich illuminants are used extensively, particularly in 3C products. At the same time, other studies also have shown that exposure to intense 'blue' light during the day leads to delayed sleep cycles and greater difficulty to fall asleep at night. It remains unclear as to whether induced sleepiness during the day is not due to a lack of good sleep at night, which may have been in turn caused by intense exposure to 'blue' light during the day!

There is no clear guidance as to how best one should balance the benefits of exposure to higher light levels of blue-rich white light that keeps us awake during the day and the disruption of normal sleep patterns that must, at least in part, be linked to tiredness and discomfort. 'Blue-blocking' spectacle and intraocular lenses, as well as sunglasses, are often designed to absorb short-wavelength light so as to control its abundant use, particularly in blue-enhanced, phosphor-coated, LED lights. Too great a reduction in short wavelength content may, however, affect yellow / blue (YB), and to some extent also red / green (RG) colour vision as well as other visual functions.

The purpose of this study was to examine the extent to which colour vision is affected by the selective filtering of short-wavelength light. Previous studies have attempted to produce a definitive answer to this question, however, in many of these studies the assessment of colour vision changes has been carried out using either arrangement tests such as the Farnsworth-Munsell 100-hue and D-15 tests or pseudoisochromatic plates tests such as Ishihara, Dvorin or HRR tests. Neither arrangement or pseudoisochromatic plate tests can achieve both high sensitivity and specificity, as even when used with the recommended illuminant, many subjects with congenital colour deficiency pass. Since the use of coloured filters is equivalent to a change of illuminant, which in turn affects the perceived luminance contrast signals for coloured objects, conventional colour vision tests are not suitable to investigate how the attenuation of blue light in the illuminant affects chromatic sensitivity.

A new method was developed for this study, based upon accurate measurements of RG and YB colour thresholds under multiple conditions of chromatic adaptation that correspond to simulated daylight (D65), on visual displays. The latter were viewed either directly, without any filter in front of the eye, or through typical, blue-blocking lenses. The third condition employed direct viewing with adapting backgrounds that were equivalent in chromaticity to D65, when filtered with selected blue-blocking filters. In addition, we have developed a model to predict how cone contrasts relate to RG and YB colour signals at threshold and how threshold cone contrasts vary with the state of excitation of S-, M- and L-cones. The model makes it possible to predict how the filtering of short wavelength light affects the S-cone retinal illuminance and hence the corresponding YB thresholds.

### KEYWORDS

colour vision | blue light | Ishihara | HRR | Dvorin | CAD test

## SESSIONS 7 & 8

# DIGITAL COLOUR AND VIRTUAL WORLD

### SESSION 7

**Technology, Colorimetry and instrumentation, spectral image synthesis, display devices (TV, video, mobilephone, overhead projector, Head Mounted Display, etc.), 2D and 3D digital printing, lighting, physics of colour, etc.**

Part 1 026 061 083 086 108 113

Part 2 001 115 116 118 136

### SESSION 8

**Interaction between natural colours and digital colours, applications. Virtual Reality, Augmented Reality, Diminished Reality, image analysis, image synthesis, graphics creation and applications (movie industry, video games, medicine, odontology, prothesis fabrication, building and construction, etc.)**

Part 1 046 053 054 059 111

Part 2 040 119 121 124

## Effect of texture on whiteness perception

Ichiro Katayama<sup>a\*</sup>, Kin'nosuke Yamaji<sup>a</sup>, Shogo Nishi<sup>b</sup>,  
Motonori Doi<sup>b</sup>

<sup>a</sup>Kindai University, Kinokawa, Japan

<sup>b</sup>Osaka Electro-Communication University, Neyagawa, Japan

\*Corresponding author: katayama@waka.kindai.ac.jp.

White cloth and white wallpaper have their own texture; however, the effect of texture on whiteness perception has not been elucidated. The purpose of this study was to clarify the effect of the surface texture of white materials on whiteness perception.

We used an LCD (EIZO CG223-W) on which we adjusted the white point to match the chromaticity of the standard illuminant D65. We showed an image of white stimulus that expressed texture through luminance modulation side by side with an image of uniform and non-textured achromatic stimulus with various levels of luminance on a gray background and then asked observers to choose the one that looked whiter. The size of each image was 189 × 189 square pixels. We prepared the following three types of texture: a pattern imitating a canvas made using Photoshop®, a pattern in which that canvas was blurred using a Gaussian blur filter, and a pattern that we obtained by photographing silk cloth with tie-dyed surface and processing it with gray scaling. All three types of texture have regular patterns in the horizontal and vertical directions. The luminance histogram of the canvas pattern image showed that the appearance frequency of the intermediate gradation luminance was low, and about 50% of all the pixels was concentrated on the maximum luminance. The luminance histogram of the image of the canvas processed with a Gaussian blur filter and the image of the photographed silk cloth showed approximately normal distribution around the average luminance. Also, for each texture image, we processed them into a 3 × 3 vertical and horizontal division, a 9 × 9 division, a 27 × 27 division, a 63 × 63 division, and a 189 × 189 division and rearranged them randomly while changing the texture anisotropy but without changing the luminance histogram.

The average evaluation results by the observers showed that, in the original state without dividing nor rearranging, the whiteness of the canvas pattern image blurred with a Gaussian blur filter and that of the photographed silk cloth were almost equivalent to that of the uniform achromatic stimulus, with 7% higher luminance than the average luminance of the textured image. This may be because the low-luminance areas of the texture were perceived as shadows caused by the unevenness of the white surface, which created a white stimulus equivalent to the one brighter than the average luminance of the textured image. In addition, this effect decreased when the anisotropy of the textured image was reduced by dividing and rearranging. This may be because the perception of the shadow caused by the unevenness of the white surface was weakened by the decrease of the anisotropy, and the random pixels with different luminance were perceived as stimuli. However, in the canvas pattern where the pixels with the highest luminance occupied about 50% of the whole image, the whiteness of the stimulus was equivalent to that of the uniform achromatic stimulus, with about 10% higher luminance than the average luminance of the canvas pattern regardless of the decrease of the anisotropy due to the division and rearrangement of the image. From the above, it was shown that the whiteness of textured white stimuli depends on the anisotropy of the texture and the luminance histogram, and it is difficult to simply estimate it from the average luminance of the textured image.

### KEYWORDS

texture | whiteness perception | luminance histogram | anisotropy

## Correlation between micro-structural features and color of nanocrystallized powders of hematite

Morgane Gerardin<sup>ab\*</sup>, Nicolas Holzschuch<sup>a</sup>,  
Alain Ibanez<sup>b</sup>, Bernard Schmitt<sup>c</sup>, Pauline Martinetto<sup>b</sup>

<sup>a</sup>Univ. Grenoble-Alpes, Inria, CNRS, Grenoble INP, LJK

<sup>b</sup>Univ. Grenoble Alpes, CNRS, Institut Néel, 38000 Grenoble, France

<sup>c</sup>Univ. Grenoble Alpes, CNRS, IPAG, 38000 Grenoble, France

\*Corresponding author: morgane.gerardin@inria.fr

Pigments are quite complex materials whose appearance involves many optical phenomena such as absorption and scattering. They are widely used in work of art and cosmetics among other things, for their coloring power. So, it is of great interest for digital representation to be able to predict the color of a pigment as a function of shape and size of its particles, or vice versa.

In this work, we have decided to focus on hematite as it is a traditional pigment, whose origin of coloration has been well discussed in the literature. Moreover, we believe that this study can be adapted to any other inorganic pigment.

Pure nanocrystallized  $\alpha$ -Fe<sub>2</sub>O<sub>3</sub> hematite powders have been synthesized using different synthesis routes to control the nucleation and growth of crystallites in solution under standard or hydrothermal conditions. X-ray powder diffraction patterns have been analyzed by Rietveld refinements in order to obtain the structural and micro-structural features of each powder: unit cell parameters, atomic positions and occupancies, average crystallite size. Monodispersity has been controlled and the shape and size of the grains composing these powders have been characterized through scanning electronic microscopy. The color of the samples has been studied by visible-NIR spectrophotometry. It follows that, for hematite, the different synthesis routes can lead to both various grain morphologies and noticeably different shades going from orange-red to purple.

In order to make the color description easier, colorimetric parameters in CIE L\*a\*b color space were deduced from the diffuse reflectance spectra. These parameters as well as diffuse reflectance spectra properties such as the positions and the width of the absorption bands were studied against structural and micro-structural parameters.

One of the observation we have made is the correlation between the hue of the sample and its grain size: for small nanocrystals (considered as spheres for the moment) with a radius within range of a few dozen of nanometers, hue is increasing with the grain size until a critical radius, of about 50 nm, where the trend is reversed. The combination of multiple physical phenomena occurring at this scale may explain this trend. In order to better understand which phenomena are at stake, simulations of different scattering models such as Mie, Rayleigh and others are underway.

We are aiming to extend our work to the understanding of the color of more natural pigments such as ochres. As an example, the investigation of parietal paintings reveals the presence of ochres but no binder. In this case, the pigments can be considered as dried powders whose color would be explained by our study.

### KEYWORDS

hematite | pigment | reflectance | crystal structure

## The Association Between Color Preference and Everyday Products

Mahshid Baniani

University of Tsukuba, Tsukuba, Japan  
Corresponding author: mahshid@geijutsu.tsukuba.ac.jp

Numerous studies have examined human preferences for simple patches of color, but is not yet clear how these abstract color preferences generalize to different object contexts (Palmer 2010, Scholss et al. 2013). The purpose of this study is to investigate and identify the association between color, preferences, assessments and everyday objects. The aim is to identify whether personal color preferences extend to everyday products when there are numerous color choices.

For this purpose, an experiment was conducted among 115 (59 female and 56 male) Japanese university students. Before the experiment, each subject was provided with a set of 24-color pencils. The name of each color was written both on the color pencil and the box. The experiment was consisted of 3 steps which were done randomly: subjects were asked to choose most/least favorite, most beautiful/ugliest, happiest/saddest, masculine/feminine, warmest/coolest, brightest/darkest color among the color pencils; subjects were given detailed realistic drawings of bedroom, t-shirt, socks, and car and were asked to consider these items as their own and color them accordingly; subjects were presented with the color of each color pencil (24 in total) and were asked how they feel about each color on a five-point Likert scale from very unhappy to very happy.

It was observed that blue hues were favorite colors of 56% of subjects followed by red (11%). Black, blue and ultramarine blue ( $P < 0.05$ ) were considered masculine colors. Feminine colors were burgundy and magenta according to female subjects, and magenta according to male subjects ( $P < 0.01$ ). Most beautiful color was ultramarine blue for male subjects ( $P < 0.01$ ), and burgundy and ultramarine blue for female subjects. It was further observed that white, ochre, brown, and dark brown were considered neutral when looking at them ( $P < 0.05$ ). Blue hues were considered unhappy. On the contrary, yellow, light yellow, gold and orange were considered happy when looking at them.

Additionally, it was observed that female subjects used colors which they considered bright, followed by their most favorite color, and colors considered beautiful in their bedroom. They used favorite and beautiful colors for clothing items; and colors they considered masculine for car. Male subjects used bright and beautiful colors in their bedroom; beautiful, masculine and favorite colors for the clothes; and their favorite color for car.

In sum, bright colors were most preferred in bedroom. The subjects of this study were Japanese and considering the fact that Japanese houses are small, this could be one of the reasons brightness is the biggest factor when choosing colors. Male subjects used their favorite color in car more than the female subjects did. The image given was of a sports car and this may have had an impact on female subjects using masculine colors. Finally, it was observed that subjects used their preferred colors in the clothing items more than the other products, perhaps due to the reason they considered these items to be the most personal of all the objects.

### KEYWORDS

color | characteristics | preferences | everyday objects

## Lights on painting – seeing and naming color-pigments illuminated with a multi-wavelength light source

Adrien Lucca<sup>a\*</sup>

<sup>a</sup>Fonds pour la recherche en art, FNRS, Brussels, Belgium

\*Corresponding author: [projects@adrienlucca.net](mailto:projects@adrienlucca.net)

Our most recent artistic research aims to enrich, deconstruct and reconstruct the very definition of «color» using an in-house made light source that allows us to program the spectral composition of light.

This research is based on color rendering – i.e. the effect that an illuminant produces on the color of objects, for example the modification of hues and their fading or accentuation – and on the counter-intuitive fact that the perceived coloration of a light and its impact on the color of materials lit by it are not necessarily correlated: white lights can have spectacular differences in terms of color rendering, and a colored light will not necessarily color the objects it illuminates.

Our light source is produced in-house with LEDs, colored filters, phosphors. We produce two metameric white lights – i.e. white lights that have the same appearance – with different narrow bands of wavelengths. The first illuminant is CR (Cyan + Red), the second illuminant is BYGA (Blue + Yellow-green + Amber). The Cyan and the Yellow-green emitters are customized LEDs that we build in-house. We call CR and BYGA «complementary» because each light approximately covers ½ of the visible spectrum and because each illuminant emits light in the zero or nearly-zero zones of the other one. This is a special case of complementarity where a white light is complementary to another white light.

CR and BYGA have radically different color rendering effects. We illuminate color-pigments with these lights in search for the most surprising effects. When illuminating a white surface with CR, the Maxwell spot becomes clearly visible: a pink transparent spot appears in the center of the field of vision. It is very difficult – and it may even be impossible – to find a metameric match of CR using another combination of wavelengths for a 2° field of view that will also be metameric for a 10° field of view. We are developing strategies to make the spectators unaware of these metameric mismatches.

Without apparent change in the perceived color of the light, the white light emitted by our light turns yellow pigments red, red pigments black, green pigments grey, pink pigments blue. These «new colors» are the result of the interaction between a spectrally adjusted artificial light and the optical properties of colored materials. We create these new colors and we give them compound names that only make sense when one experiences that the same material can change before our eyes: a “black-red” is sometimes red, sometimes black, so are «blue-pink», «lemon-red», «green-gray».

The color changes are produced in time without the whiteness of the light being modified and therefore without the attention being paid to the light. These moving objects seem to «suffer» from the light and communicate it to us, as if they were alive. The experience of the color of a material varying independently of that of the materials around it makes one think of an image manipulation software that would have magically transposed into the usual domestic space. We believe that if the «color» of an object means not only its actual color «here and now», but means the field of its possible variations, the definition of color itself is renewed.

### KEYWORDS

contemporary art | pigment | multi-wavelength | color names | colorimetry | definition of color

## The color of Modigliani's paintings in France (1908-1919)

Anaïs Genty-Vincent<sup>ab</sup>, Ruven Pillay<sup>a</sup>,  
Marie-Amélie Senot<sup>c</sup>, Michel Menu<sup>ab</sup>

<sup>a</sup>Centre de Recherche et de Restauration des Musées de France (C2RMF), Paris, France

<sup>b</sup>Chimie-ParisTech, PSL, Institut de Recherche de Chimie-Paris (IRCP), Paris, France

<sup>c</sup>LaM, Lille Métropole Musée d'art moderne, d'art contemporain et d'art brut, Villeneuve d'Ascq, France

\*Corresponding author: anais.genty@culture.gouv.fr

Amedeo Modigliani (1884-1920) was a renowned Italian painter and sculptor, who developed a characteristic and unique style over the years. Only two technical research projects have previously been undertaken on his paintings: one by the C2RMF in 1981 [1] and another by the Tate in 2018 [2]. New scientific research is currently being undertaken through the 'Modigliani and his Secrets'\* project, which was set up with the aim to acquire a better knowledge on the materiality of Modigliani's masterpieces, as well as to acquire a better understanding of his studio practice and pictorial technique. The corpus covers the entire work produced by Modigliani in France from 1908 to 1919 and consists of every work by Modigliani that is within a public collection museum within France i.e. 25 paintings and 3 sculptures, from 10 museums.

In this paper, we will focus on the evolution of Modigliani's color palette, which is intrinsically related to the evolution of his pictorial technique. The characterization of the color palette of each painting is based on an identical broad multi-analytical protocol which includes technical imaging (visible/UV/IR, X-ray radiography), optical microscopy, macro-X-ray fluorescence (MA-XRF), hyperspectral imaging in both the visible-near infrared (VNIR) and short-wave-IR (SWIR), in-situ X-ray diffraction (XRD) and stratigraphic analysis of cross-sections by scanning electron microscopy coupled with energy-dispersive X-ray spectrometry (SEM-EDS). In order to study and provide quantitative measurements of the color palette, we have used the hyperspectral data, which provides accurate high resolution spectra at each and every point on the painting. From these spectra, a precise colorimetric map of each painting has been produced. The representative colors found within the palette were then automatically extracted from the colorimetric maps through K-Means clustering in order to produce a palette of the different colors found within each painting. In order to make sense of this color palette, it is also necessary to identify the pigments and materials used. Indeed, the identification of the artistic materials used by Modigliani highlights his creative process. He was a brilliant colorist with a specific and distinctive gesture. Modigliani used a wide range of white pigment providing various degree of opacity: lead white, zinc white, lithopone and barite. Regarding the pigments, vermilion, red lake and red ochre are mainly used for red tones, Prussian blue, ultramarine blue and cobalt blue for the blue tones, chrome green and emerald green for green tones and earth ochre, as well as different yellow pigments such as cadmium yellow and chrome yellow in the yellow and brown hues.

Paradoxically the virtuosity of Modigliani's use of color is especially apparent in the dark areas. Those that appear black at first glance, were made with bone black pigment, often mixed with a large variety of pigments of different colors such as Prussian blue, cobalt blue, chrome green, emerald green, iron oxides, red or yellow, vermilion depending on the desired tone. His color palette evolved over the years with the paint layers becoming thinner and thinner to create an artistic style that become more refined. Indeed, even if the nature of the pigments may differ from one painting to another, his palette seems to become more restricted and brighter in his later portraits (1917-1919).

The use of complementary scientific methods involving chemical, imaging and colorimetric analysis has provided unique results which have enabled us to reveal and quantify his color palette as well as his unique pictorial technique over his short artistic life.

[1] S. Delbourgo and L. Faillant-Dumas, 'L'étude au Laboratoire de Recherche des Musées de France' in B. Contensou and D. Marchesseau: Amedeo Modigliani, Musée d'art Moderne de la Ville, 1981, pp. 20-47.

[2] Collective work, 'The Modigliani technical research study', The Burlington Magazine, Vol. CLX, 2018, No 1380 pp. 181-195 / No 1381 pp. 311-324 / No 1392 pp. 394-407.

\* The project is co-lead of by the LaM and the C2RMF, with the close collaboration of the CNRS through the UMR 8247-Chimie ParisTech/C2RMF and the USR 3290-MSAP, and all French museums involved. The project is financed by the Service of the French Museums, Lille Metropole, LaM and DRAC Haut-de-France.

### KEYWORDS

Amedeo Modigliani | pictorial technique | colorimetry | color palette | colorist



## Study on Dynamic Adaptation Properties under the Chromatic Colored Light and the Glare Source

Youko Inoue<sup>a\*</sup>, Yoko Ikegami<sup>b</sup>, Haruka Hamana<sup>c</sup>,  
Ayana Kishima<sup>b</sup>

<sup>a</sup>The Open University of Japan, Nara, Japan

<sup>b</sup>Nara Women's University, Nara, Japan

<sup>c</sup>Kyushu University, Fukuoka, Japan

\*Corresponding author: youkoinoue@cc.nara-wu.ac.jp

The luminance in the visual field, that is the light stimulation to eyes, changes frequently. However, the certain time is necessary for adaptation to the changing of visual field luminance, and a temporary deterioration of visibility may occur in the adaptation transition. Such a situation should be evaded from the viewpoint of safety. Therefore, it is necessary to clarify adaptation properties for the visual environmental plans to be safe, and to be comfortable. In addition, there are various glare sources in the visual field. Furthermore, today, we can use various light colors because new light sources such as the LED have been appeared. This paper reports the influence of the light color and the glare source on light/dark adaptation process in the range of the luminance change to produce in everyday life. The experiment is the measurement of time until barely recognize a visual object. The time progress of luminance different threshold is determined by results of the measurement time. The visual object is a circular of the achromatic color, the size is four minutes in diameter and the contrast is from 0.01 to 0.80. The range of background luminance is 0-1000 cd/m<sup>2</sup>. The light color is blue, green, yellow, red, and white. The luminance of glare sources is 30500 cd/m<sup>2</sup>. The size of the experiment booth is H1.7m × W1.5m × D2.4m. The interior color is white. The subject is three young women aged 21-23 and their binocular visual acuity is 1.34-1.48. The procedures are as follows.

- 1) Just after the subject has finished wearing an eye mask for one minute, the background luminance L1 of before changing is presented, and at the same time, visual objects are presented.
- 2) The subject reports the visual object which she can barely recognize at every designated time.
- 3) Just after the scheduled time has passed, the background luminance changes into luminance L2 of after changing.
- 4) The subject informs a time when she is able to recognize a visual object sequentially by pushing the key.

Examination and data analysis provided the following results.

- 1) In all of chromatic colored light used in this experiment, the luminance difference threshold decreases with progress at time in both of the light adaptation process and the dark adaptation process.
- 2) The inclination of decreases of the luminance difference threshold with elapsed time is almost equal regardless of the before luminance L1 and the after luminance L2, and in each adaptation of the light and the dark.
- 3) As same as past knowledge of the white light, the relations between the luminance change ratio and the adaptation completion time is recurred by a straight line. And the inclination of the regression line is equal without depending on a light color.
- 4) In a transient process of adaptation, the increase of adaptation luminance by the glare sources is equal to that of the steady adaptation. In other words, the influence of glare source on adaptation luminance is same regardless of transient or steady.

The experimental result is being successively analyzed. A prediction function of the adaptation luminance will be suggested by explanation variables which are the adaptation luminance of before changing, the luminance distribution of after changing visual field, the elapsed time after the change, et. al. And for safe life space creation, the dynamic evaluation method of adaptation luminance will be suggested with the function.

### KEYWORDS

dynamic adaptation properties | chromatic colored light | glare source | adaptation luminance | luminance change ratio

## A fractal polyhedron packing of the RGB space for intuitive high-dimensional data visualization

Kai Berger\*

\*visual-data-science.org

In this paper I propose a new approach to visualizing data with up to 4 dimensions by sorting them by relevance and assigning the two most important dimensions to positions on a polyhedron that is fit in the RGB cube such that each corner touches a fully saturated primal color (red, green, blue, cyan, magenta, yellow). Prior research suggests the use of an 8 faced polyhedron for the fit.

Naïve color schemes for the mapping of 2 dimensions rely on mean-shifting the data and mapping it to RGB. Others may include a mapping into HSV. My approach maps the HUE circle from HSV onto the unit sphere in a way that every prime color is mapped to one octant of the sphere. I have tried several color assignment schemes for the problem to map an arbitrary surface normal rotation to an intuitively understandable color. However mapping the first 2 dimensions to a regular color scheme fails with standard color spaces, like RGB, Lab, HSV, NTSC. Either the prime colors are unevenly distributed, or not visited at all. E.g., a RGB mapping equates certain unit axes to less saturated colors that a significantly distant from prime colors. Using a polyhedron approach instead ensures an intuitive use of the most saturated prime colors.

I then assign the next dimension to the saturation of the polyhedron by effectively interpolating between pure gray and the fully saturated polyhedron. Finally, the least relevant dimension is assigned to the fractal replica of the polyhedron, using an iterated function system, which is positioned at  $1/(2+\epsilon)^n$  and  $1-(1/(2+\epsilon))^n$  of the original polyhedron. Note, that this dimension needs to be discretized in order to avoid overlap of color values. For example, the least relevant 4<sup>th</sup> dimension can be discretized into 7 steps and assigned to seven polyhedra. The polyhedra are disjoint and thus don't touch each other in the RGB space. In theory, this process of generating and placing smaller polyhedra can be repeated infinitely but in practice converges at pitch black and pitch white after 4 iterations. At this point, the fourth dimension has to consist of integer data values only in order to avoid interference and overlap between polyhedron. This ensures an intuitive reading of data colored with the scheme without confusion.

This way a visualization is achieved with the most relevant two dimensions effectively mapping to a sphere, where at every 90 degrees a different primal color is located. The other two dimensions then are visualized through saturation and brightness.

### KEYWORDS

color space | color mapping | data visualization | fractal space packing

## Effect of lighting on visual appearance of Japanese woodblock print painting (Ukiyo-e) for Spanish observers

Shino Okuda<sup>a\*</sup>, Satoko Taguchi<sup>b</sup>, Katsunori Okajima<sup>c</sup>,  
Luis Gómez Robledo<sup>d</sup>, Manuel Melgosa<sup>d</sup>

<sup>a</sup>Doshisha Women's College of Liberal Arts, Kyoto, Japan

<sup>b</sup>Tokyo University of the Arts, Tokyo, Japan

<sup>c</sup>Yokohama National University, Yokohama, Japan

<sup>d</sup>University of Granada, Granada, Spain

\*Corresponding author: sokuda@dwc.doshisha.ac.jp

Recently, LEDs are being used for museum lighting, but how to achieve optimal lighting for visitors is still an open question. In the present study, we focused on Ukiyo-e, which is a Japanese woodblock print painting. We conducted a subjective experiment on the visual appearance of Ukiyo-e under different lighting conditions, considering observers from Spain who are not familiar with this kind of paintings.

We employed two kinds of Ukiyo-e, drawn by Toyohara Kunichika, who is a famous Ukiyo-e artist. In Ukiyo-e (a), "Mitate hashi zukushi Nihonbashi", Parody of Collection of Bridges / Nihon-bashi Bridge (1873), an actor of Kabuki wearing kimono in indigo and white was drawn on a red background. In Ukiyo-e (b), "Edo meisho awase no uchi Osho Jiro No.7", Famous Views of Edo / Osho Jiro (1867), a Kabuki actor wearing a kimono in blue-green and dark blue was drawn on a black background. We measured the spectral reflectance of these two Ukiyo-e using a 2D spectroradiometer, and next we generated simulated digital images of each Ukiyo-e under 12 illuminants, nine CIE LEDs illuminants proposed in CIE 015:2018 (B1, B2, B3, B4, B5, BH1, RGB1, V1 and V2) plus three conventional CIE illuminants (standard illuminant A, supplementary standard illuminant D50, and standard illuminant D65), considering three illuminance levels: 50lx, 200lx and 500lx. In total, we generated 78 images and each one was presented to observers using a calibrated display. Spanish participants observed each Ukiyo-e, and were asked to scale the appearance with 11 pairs of adjectives ("dull - vivid", "heavy - light", "muddy - clear", "old - new", "cold - warm", "inactive - active", "static - dynamic", "traditional - modern", "moderate - high-grade", "uncomfortable - comfortable" and "ugly - beautiful"), using a 7-steps scale. They also evaluated "preference of lighting" with a numerical scale from 1 (not at all preferred) to 10 (absolutely preferred).

The results showed that Ukiyo-e (a) including much red colour looked most vivid under the RGB illuminant in 500lx, while Ukiyo-e (b) consisting of blue colours looked most vivid under the D65 and B5 illuminants in 500lx. Ukiyo-e (a) looked most comfortable under illuminant B3 in 500lx, and most uncomfortable under illuminant B1 in 50lx. However, Ukiyo-e (b) looked most comfortable under illuminant B4 in 500lx, and most uncomfortable under illuminant B2 in 50lx. Also, Ukiyo-e (a) looked most beautiful under D65 in 500lx whereas looks most ugly under illuminant B1 in 50lx. Ukiyo-e (b) looked most beautiful under illuminant B4 in 500lx, and most ugly under illuminant BH1 in 50lx. Both Ukiyo-e (a) and (b) were increasingly preferred with higher illuminance levels. Specifically, illuminant B3 was most preferred for Ukiyo-e (a), while illuminant B5 was most preferred for Ukiyo-e (b).

In conclusion, visual appearance of Ukiyo-e for Spanish observers is largely affected by the lighting conditions, and the preferable illuminant depends on the specific colours of these paintings.

### KEYWORDS

light colour | museum lighting | Ukiyo-e | LED illuminant

## Spatio-temporal Factors of Colored Light Sequences in the Built Environment

Jean-Luc Capron<sup>a\*</sup>

<sup>a</sup>Université catholique de Louvain, Louvain-la-Neuve  
<sup>\*</sup>Corresponding author: jean-luc.capron@uclouvain.be

When designing light shows by means of colored light sequences, it is essential to take into account all the spatial and temporal factors, as well as their interactions. These two dimensions must be approached in their multiple facets, taken individually and in their interactions.

The analysis of the different factors is based on the designs made by architecture students for a light show supporting a choir concert in a confined and defined space. The colored lighting was carried out using RGB LED spotlights, linear and point type. The variations in color and luminous flux were specified using a lighting controller software. During the event, the data were transmitted to the projectors according to the DMX512 protocol. The lighting aims was to create an atmosphere in harmony with the songs, and for this to modify the spatial and temporal perception of the spectator (viewer / listener).

The concert / light show space consists of a large space with a long backdrop wall, with, in its center, a square plan space materialized by four large columns, also of quadrangular section. This elementary spatial structure allows to isolate more easily each of the spatial components and to determine their interactions. The light sources are linearly arranged for uniformly illuminating the background and in a spotwise manner to illuminate each of the faces of the columns. This will allow to isolate the projected lights from the resulting colored light on the illuminated surfaces, and to define a binary type typology.

The perception of physical space is altered not only by the fact that the surfaces are revealed, or not, by their lighting, but also by the color and the intensity of the luminous flux, itself resulting from the additive synthesis, respective to the RGB LEDs flows. In addition to the physical perception of physical space, there is the spatial dimension of the perception of color in itself and of the neighboring color contrasts.

Spatial perception is also modified in its temporal dimension by the sequential appearance / disappearance of colored lights, which modulate perception according to rhythms. These rhythms, well associated with the auditory dimension, also modify spatial perception. While the resulting spatial perception in turn influences the perception of the auditory media.

As the final goal of this inquiry is to develop design strategies and methodologies that meet the requirements and specificity of spatio-temporal sequences by means of colored lights, the analysed setting of colorful and dynamic light in a built environment, allows to isolate each space and time factor (spatio-temporal factors) and specify both of them, taken alone and in interaction.

### KEYWORDS

*colored light | spatio-temporal | built environment | human perception | lighting design*

## The “Haut de Jaurès” project in Brest: the collective reconquest of a street identity - from the former sailors’ district to 3D colour modelling

Anne Petit<sup>a</sup>\*

<sup>a</sup>PhD, Colorist architect, independent researcher  
\*Corresponding author: [annepetit.archi@gmail.com](mailto:annepetit.archi@gmail.com)

The “Haut de Jaurès” project is the collective research of a main street identity through the use of 3D colour modelling. Inhabitants and a group of colorists and architects worked together at the elaboration of a colouring guide for the street, using various methods and interactive tools including a large and immersive 3D modelling to test the colour schemes.

Located in the western part of Brittany, in France, the port city of Brest has had a close relationship with colour planning for the past thirty years. Largely destroyed after the Second World War, the city has launched many innovative colour projects including the Top of Jaures project carried out since 2016.

Starting from the historic city centre of Brest, the Jean Jaurès Street is a large urban artery, 1.8 km long with a tramline. Its upper part, called the «Haut de Jaurès», suffered from the abandonment of shops and from a feeling of insecurity. This neighbourhood, located in the protected historical area, is made of heterogeneous buildings. This important aspect challenges the chromatic atmospheres suggested for the street.

Historically very lively and dynamic, the identity of the district goes back to the time when sailors were on leave and stayed in the «Red Pillar» area, with its bars, clubs, restaurants, and cinemas including “Le Celtic” and its monumental architecture.

Aware of the role of colour in improving the living environment and the re-appropriation of the street by its inhabitants, the city of Brest commissioned a team of architect-colorists, expert architects in citizen participation, and graphic designers from the GIS service of the city, to work in collaboration with the inhabitants, traders and users of the district.

The project combines citizen participation workshops (colour culture awareness workshops, visits and mobile mapping workshops, workshops for handling coloured materials, and time for debates) and an immersive experience in a 3D model. The consultation phase resulted in the designing of a specific colour guide for the “Haut de Jaures” street, personalized support, and subsidies for facades restoration since 2016.

The article tells the story of the implementation of this project and the progress of this collective experience, including the creation and use of an immersive 3D model of the 700m long street.

The 3D tool offered an interesting augmented reality giving the possibility to change the time of the day, the sunshine, the weather conditions, and therefore the quality of coloured shadows. This aspect allowed the inhabitants to test different urban ambiances. The model also allowed residents to test the two colour schemes that were suggested to them, by moving along the street, and by activating or deactivating certain options. In this particular case, the use of the 3D model was an opportunity to measure the complexity of the reproduction of an in-situ perception, especially in the context of the projection of different colouring schemes on facades.

### KEYWORDS

*colour planning | urban landscape | 3D model | citizen participation | colouring schemes*

## Can fixation-point and key-point coincide on cultural heritage color paintings?

Hermine Chatoux, Noël Richard, François Lecellier,  
Christine Fernandez-Maloigne

Univ. Poitiers, XLIM, CNRS UMR 7252, F-86000 Poitiers, France

This article compares the key-point extracted with a color key-point detector and the location of fixation point thanks to an eye-tracking experiment. We hypothesize the first fixation points should correspond to key-points with the most significant gradients.

A fixation point, is a point look at by a human for more than 50 ms. To extract this point, we conducted an experiment with an eye-tracker. Twenty images are presented to an observer one at a time for 30 s, the eye-tracker follows the eye-movement and records the fixation point locations and durations. The presented images are paintings from cultural heritage, carving or sculpture from the X<sup>th</sup> to the XIV<sup>th</sup> centuries. Thirty-two observers data are kept after the experiment, five other persons played the experiment but due to glasses or movements during the recording, their results has to be disregarded.

A key-point is an area around a point which is specific enough to be recognize in other similar images. A key-points series has to be able to define the image. In parallel to the eye-tracking experiment, we developed a color key-point detector. It is based on the Harris corner detector and the full-vector gradient considering the channel characteristics to measure a color gradient. Therefore, this detector is linked to the sensor. To be closer to the human vision condition, we have transformed the initial images in the LMS color space, so the color space of the eye sensor. The detector focuses on extracting corners. A response value is extracted with each key-points corresponding to the strength of the key-point. The higher the response value, the more probable the location is to be a corner.

With both results, we can compare fixation points with key-points. First of all, we have calculated the percentage of fixation point location that correspond to a key-point location. Between 30% to 50% of the fixation points coincide with a key-point. As we haven't considered the central bias induced by the human vision, most of the key-points without matching are on the image edges.

In a second analysis, we displayed the number of matching key-points over the number of fixation points at a given time. The ratio decreases with the observation time. It proves our initial hypothesis. The first fixation points are consistent with key-point detection. This seems to induce that in a first analysis, the human vision looks for corner in images. The correlation varies in strength depending on the images analyzed. However, due to the age of the paintings analyzed, half of them are unfortunately degraded. On these images, the correlation is weak. Even if the human brain, is able to complete a part of the missing information, the corner detector will focus on both the painted areas and the edge between paint and plaster. These last areas won't be the focus of the human eye.

Overall, several of the first fixation points correlate with high response key-points detected with our method. This comparison supports our conjecture based on strong correlation between the first fixation points corresponding to the pre-brain analysis and the corner key-points extracted with our detector. A limit of this analysis is that the key-points are selected to be corners while fixation points can be a corner or the center of a uniform area. Therefore, this study should be completed with a one comparing a blob detector and the fixation point. This can be a response on the battle corner/blob detection: both are of interest in regard to human vision! The comparison should be more developed to better understand the link between fixation points and key-points detection. In fine, this could guide the future key-point detector to a better harmony with the visual perception and brain analysis.

### KEYWORDS

eye-tracker | key-point | fixation point | saliency

## Mixing models in close-range spectral imaging for pigment mapping in Cultural Heritage

Federico Grillini\*, Jean-Baptiste Thomas, Sony George

The Norwegian Colour and Visual Computing Laboratory, NTNU-IDI, Gjøvik, Norway

\*Corresponding author: federigr@ntnu.no

Pigment mapping is a fundamental tool in the field of conservation of cultural heritage paintings. It allows the identification of the pigments, their relative concentrations and their monitoring. The techniques used should limit the distortion in the painting, and several non-invasive and non-destructive methods have been developed. Hyperspectral Imaging allows to capture the spatio-spectral characteristics of the painting. However, the captured data are based on the mixture between illumination, material, and camera properties. We consider state-of-the-art methods to discard illumination, and we focus on the mixing of pigments in the painting using the imaging methods. In remote sensing, inverting the identification of different spectral signatures from a pixel value is referred to as spectral unmixing.

In this work, we consider several mixing models and their unmixing. In addition to standard additive, subtractive and hybrid models, we also adapt the Logarithmic Image Processing framework to the mixing problem. The Logarithmic Image Processing framework proposes to consider images in transmission, it performs well on several applications particularly because it encompasses the limits dictated by the encoding (no clipping or normalization). We assume that the mixtures of spectra can also follow this framework, especially in the case of pigments, where we can speculate an arrangement in which light is transmitted and reflected. All models are subject to two constraints about the concentrations: non-negativity and sum-to-one.

We realized a set of 175 oil painted mock-ups using the following Kremer pigments: Ultramarine Blue, Gold Ochre, Vermilion, Naples Yellow, Viridian Green, Novoperm Carmine Red and Kremer White. Only mixtures containing up to 3 pigments are considered, and the ground truth of concentrations is recorded, using a precision scale. After hyperspectral acquisition, the concentrations are retrieved with a Nelder-Mead optimization. The algorithm tries to maximize a function based on the Peak Signal-to-Noise Ratio between the ground truth of the mixture's spectrum and the reconstructed one. The optimization is run for every mixing model, and the best result based on a metric that combines PSNR and accuracy of the estimated concentrations, is selected.

From both standpoints of spectral reconstruction and concentration accuracy, the purely subtractive model resulted to be the best suited model in describing the mixture of pigments in oil painting.

In order to demonstrate such model, a study-case oil painting was realized for the occasion, utilizing the same palette of Kremer pigments. The approximated ground truth (not weighted) of 12 areas of the painting is known. Pigment mapping inverting the subtractive model is performed, and the performances analyzed on the 12 reference areas. The results confirm the validity of the mixing model, but also highlight a few shortcomings in identifying specific pigments, leaving room for improvement.

### KEYWORDS

*pigment mapping | cultural heritage | optical model | spectral unmixing*

## Measuring and mapping the colours of the Bayeux Tapestry using hyperspectral imaging

Clarisse Chavanne<sup>a\*</sup>, Arnaud Daret<sup>b</sup>, Pascal Buléon<sup>c</sup>,  
Clémentine Berthelot<sup>d</sup>, Antoine Verney<sup>d</sup>, Philippe Walter<sup>a</sup>

<sup>a</sup>Sorbonne Université, CNRS, Laboratoire d'archéologie moléculaire et structurale, Paris, France

<sup>b</sup>Université de Caen Normandie, Centre de ressources technologiques pour les TIC (CERTIC),  
Direction du système d'information, Caen, France

<sup>c</sup>Université de Caen Normandie, CNRS, Maison de la Recherche en Sciences Humaines, MRSH, Caen, France

<sup>d</sup>Musées de Bayeux, Bayeux, France

\*Corresponding author: clarisse.chavanne@upmc.fr

The Bayeux Tapestry, deposited by the French State at the Museum of Bayeux, is an embroidery of woollen threads on a linen canvas of almost 70m long. This object is a masterpiece of Roman art and a unique source for understanding the creation of the Anglo-Norman kingdom. It is an extremely discussed topic of study, despite the lack of resources providing information on its origin. However, few studies related to the scientific analysis of the Bayeux Tapestry as a textile object were conducted until now. The most important one was carried out in 1982 with a sampling of woollen thread and chemical analyses, allowing the identification of the dyes used during the making of the Tapestry. One objective of our research on the colours of the Bayeux Tapestry, started in January 2020, is to obtain information on the colours through non-invasively analyses, using hyperspectral imaging.

Hyperspectral imaging makes it possible to capture the reflected light of a sample lit by known light in an absolute manner. For the analyses of the Tapestry, we used VNIR (Visible-near infrared – 400-1000nm) camera (Specim, Oulu, Finland) built with a CCD detector. This camera allows for a spectral resolution of 2.8 nm and the experimental device has been adapted to have a spatial resolution of 150 µm at any point in the scan.

This communication will present the first results obtained on 14 m of the Bayeux Tapestry. By comparing the spectra measured with those obtained from woollen threads dyed in the laboratory with natural substances used in medieval times (indigo, madder and weld), we will show that it is possible to obtain spatial information on the nature and concentration of the dyes and to represent them in the form of distribution maps. These data will then be added to the Spatialized Document Information System (SDIS) developed at the University of Caen Normandy. It will allow the visualization of the complete representation of the Tapestry with the data on the colours spatially referenced.

### KEYWORDS

natural dyes | wool | hyperspectral imaging | SDIS



## Dominant color and image color palette retrieval from complex images

Raza Aiman<sup>ab\*</sup>, Jost Sophie<sup>a</sup>, Dubail Marie<sup>b</sup>

<sup>a</sup>Laboratoire Génie Civil et Bâtiment, Ecole Nationale des Travaux Publics de l'Etat, Université de Lyon, 69120 Vaulx en Vélain, France

<sup>b</sup>Essilor International, Paris, France

\*Corresponding author: aiman.raza@entpe.fr

Most studies on colorimetry limit their color analysis on uniform patches. Even though characterizing single patches of color is crucial for determining various properties (for color management, tolerances of production, color rendering indexes, etc.), sometimes it may not be sufficient in relation to complex scenes. In the field of architecture, artworks, textile and even in digital graphic industry, color imaging is often used to represent, analyze and model complex scenes. To better represent the visual perception of the observers, it can be useful to determine the color composition of such natural or synthetic scenes by taking into account the entire set of colors and their locations. To do so, color palette creation can be used to evaluate the entire test scene and describe its major dominant colors.

Various color palette systems exist in the literature, based on color histograms, color correlograms, image segmentation or a combination of different techniques. Nevertheless, many of these approaches tend to be either very basic with a simple implementation, or, be highly advanced but complicated to implement.

In the scope of this study, a fast and simple color classification algorithm was developed based on k-means++ algorithm for quick color analysis of complex images. The algorithm treats Gaussian blurred CIELAB version of the original image to segment the scene in clusters of six or less colors with the highest representation in the image. It identifies the colors with the help of ISCC-NBS color terminology and locates them on the scene. The algorithm was tested for accuracy by the means of a psycho-visual experiment. The results show a coherent dominant color classification with human visual perception. The algorithm is simple yet effective for quick analysis of complex color images to retrieve automatically the color composition.

### KEYWORDS

*complex images | color palette | dominant color*

## Multispectral imaging of healthy and diseased red blood cells using confocal microscopy

Laura Rey-Barroso<sup>a\*</sup>, Mónica Roldán<sup>be</sup>,  
Francisco J. Burgos-Fernández<sup>a</sup>, Ignacio Isola<sup>ce</sup>,  
Anna Ruiz-Llobet<sup>d</sup>, Susanna Gassiot<sup>cd</sup>, Meritxell Vilaseca<sup>a</sup>

<sup>a</sup>Centre for Sensors, Instruments and Systems Development, Technical University of Catalonia, Terrassa, Spain

<sup>b</sup>Unit of Confocal Microscopy, Service of Pathological Anatomy, Pediatric Institute of Rare Diseases, Hospital Sant Joan de Déu, Esplugues de Llobregat, Spain

<sup>c</sup>Laboratory of Hematology, Service of Laboratory Diagnosis, Hospital Sant Joan de Déu, Esplugues de Llobregat, Spain

<sup>d</sup>Service of Pediatric Hematology, Hospital Sant Joan de Déu, Esplugues de Llobregat, Spain

<sup>e</sup>Institute of Pediatric Research, Hospital Sant Joan de Déu, Esplugues de Llobregat, Spain

\*Corresponding author: laura.rey.barroso@upc.edu

Red blood cells (RBCs) alterations can cause very severe syndromes if they are not detected early enough during childhood. In some of these syndromes, hemoglobin, which is the protein in charge of oxygen transportation, is known to have alterations in the polypeptide chains that form its quaternary structure. An unbalanced production of either one of the two kinds of these polypeptide chains (alpha or beta) produces a quantitative alteration in the hemoglobin of patients suffering from thalassemia. This can cause very variable manifestations in patients, from no manifestations at all or small blood count alterations, to RBCs premature destruction with severe anemia, high morbi-mortality and low life quality.

RBCs morphological analysis through conventional optical microscopy is essential in the diagnosis of thalassemia, as well as the collection of RBC indices such as their mean corpuscular volume and amount of hemoglobin per RBC. However, these techniques might be not specific enough when discriminating among degrees of thalassemia or among other causes of anemia, and most patients need to undergo complex and expensive genetic studies to be correctly diagnosed. For this reason, diverse studies in the state of the art have tried alternative ways to analyze RBCs, for instance, collecting their emission and absorption spectral traits in the ultraviolet (UV), visible (VIS) and infrared (IR) ranges by using spectrometers and spectrofluorometers. On the other hand, confocal microscopes have also been used as a means of studying RBCs morphological and physiological properties. Particularly, multispectral imaging combined with confocal microscopy would allow capturing the light emitted from a given plane of focus with nanometric precision in depth and from a wide spectral range, providing both tridimensional and spectral information.

Therefore, this preliminary study explores the possibilities of multispectral imaging combined with confocal microscopy as a diagnostic tool for thalassemia in pediatric patients. RBCs from patients with different forms of alpha-thalassemia and iron deficiencies (including anemia), as well as healthy (control) subjects, were analyzed under a Leica TCS SP8 confocal microscope. This is a powerful imaging tool equipped with a detection unit that allows spectral discrimination using hybrid cameras, which are capable of detecting signal with high sensitivity coming from RBCs from 400 nm to 790 nm. It incorporates two lasers for excitation, a diode laser with an emission of 405 nm and a white laser that emits from 470 nm to 670 nm combined with an acoustic-optic tunable filter. It also includes depletion lasers at 592 nm, 660 nm and 775 nm to de-excite the outermost part of molecules to be able to visualize structures at nanometric scale.

Multispectral images from diseased RBCs exhibited autofluorescence when excited at 405 nm and their emission was collected in the spectral range from 425 nm to 861 nm with a spectral window of 20 nm and in steps of 7 nm. Two experimental descriptors calculated from the mean emission intensities at 502 nm, 628 nm and 649 nm allowed us to discriminate between the aforementioned diseased cells and healthy ones. According to the results obtained, multispectral imaging combined with confocal microscopy might serve as a tool for the diagnosis of thalassemia.

### KEYWORDS

*multispectral imaging | confocal microscopy | thalassemia | red blood cell | autofluorescence*

## Color Quality Effects of White Light LEDs for Illuminating Color Proof in Comparison with Soft Proof

Yu-Zhi Oua<sup>a\*</sup>, Hung-Shing Chen<sup>b</sup>

<sup>a</sup>Graduate Institute of Color and Illumination Technology, National Taiwan University of Science and Technology, Taipei, Taiwan.

<sup>b</sup>Graduate Institute of Electro-Optical Engineering, National Taiwan University of Science and Technology, Taipei, Taiwan.

\*Corresponding author: gt10011@gmail.com

Because of the flexibility of LED, it can be modified to adapt to difference workspaces freely, and users can easier catch the ideals of designer. At present, it still tends to adopt 5000 K illuminant in the printing industry. However, the white point on general desktop computer monitor is designed based on 6500 K. Is the 5000 K white light LED a good light source used in colour image comparison between hardcopy and softcopy? It needs to verify by further inspection. The aim of this study is to evaluate the performances of hardcopy images under different colour quality of white LEDs applying in printing industry. The Tealumen multi-LED system with 16 narrow-band LED channels across the visible spectrum is used to construct the spectral power distributions (SPDs) of the testing LEDs. In the experiment 1, all of the testing light sources are set to the same illuminance level (500 lx), but different color temperatures. This study discusses the relations between the colour quality and the 4 color rendering indexes of the illuminants, which are CCT, R<sub>f</sub>, R<sub>g</sub>, and gamut shape of vector color graphic. About 15 observers with normal color vision make visual assessment by observing 5 printed images. In Experiment 1, 4 kinds of SPDs are set to R<sub>f</sub> =95 and R<sub>g</sub>=100, and their correlated color temperature (CCT) are 5000K, 5500 K, 6000 K and 6500 K respectively. In Experiment 2, the testing SPDs are designed according to the following IES TM-30 color rendering indexes combinations: 2 levels of R<sub>f</sub> values, 3 levels of R<sub>g</sub> values, and 2 kinds of gamut shapes. Each observer is asked to make the visual assessment between the printed image (color proof) and the reference one (soft proof). One printed image illuminated by the chosen test source in turn and the reference image with the same content shown on the reference monitor (Adobe RGB-calibrated LCD) are located side-by-side at the same time. The observers are asked to rate the scores for test printed images using the six-level categorical judgment method according to the following psychological indexes: (a) similarity, (b) preference, (c) vividness, and (d) naturalness. In total, 1320 assessments were accumulated (4 assessment items × 5 images × 11 sources × 15 observers) in this study. The test images include 3 natural images and 2 painting images. The testing results and discussions will be reported in the full paper.

### KEYWORDS

correlated color temperature | spectral power distributions | IES TM-30

## Three-dimensional acquisition and modeling: applications in Human and Social Sciences

Thibaut Delval<sup>a</sup>, Cyril Giorgi<sup>b</sup>, Louis Hugonnier<sup>c</sup>,  
Maximilien Lhomel<sup>d</sup>, Sylvain Rassat<sup>e\*</sup>,  
François-Joseph Ruggiu<sup>e</sup>.

<sup>a</sup>Centre Scientifique et Technique du Bâtiment, 14 boulevard Newton, 77447 Marne-La-Vallée.

<sup>b</sup>Inrap, Centre de recherches archéologiques, 32 rue Délizy, 93692 Pantin cedex.

<sup>c</sup>Inrap, Centre de recherches archéologiques, 3 Rue du Commandant Gérard, 02200 Soissons.

<sup>d</sup>Cabinet géomètre expert Boulogne.

<sup>e</sup>Centre Roland Mousnier, UMR 8596, CNRS-Sorbonne Université, 1, rue Victor Cousin, 75230 Paris cedex 05.

\*Corresponding author: sylvain.rassat@cnrs.fr

For some time now, 3D acquisition and modeling techniques have revolutionized the use of spatial data. For the humanities, the exploratory fields are extremely extensive. The digital preservation of architectural heritage, the analysis of soil surfaces or urban fabrics are now linked to problems of spatial planning, historical or even archaeological.

Some scientific projects can now combine the chromatic richness of a photogrammetric recording, the Euclidean precision of a laser lift and a standardized modelling or Building Information Model (B.I.M).

This presentation is based on three case studies combining these high-density spatial data acquisition techniques associated with the 3D B.IM. L'oppidum du second âge du fer de Vermand (Aisne, France), the study of the city of Charleville (Ardennes, France) as well as the chapels of Osiris in Karnak (Egypt), will illustrate this decisive evolution

### KEYWORDS

photogrammetry | scanner | building information model | 3d | digital heritage

## The impact of colour and light on the music emotion

Tzuhao Liu<sup>a</sup>, John Hutchings<sup>b</sup>, Ming Ronnier Luo<sup>a,ab\*</sup>

<sup>a</sup>Zhejiang University, Hangzhou, China

<sup>b</sup>School of Design, University of Leeds, UK

\*Corresponding author: M.R.Luo@leeds.ac.uk

Experimental data shows that music and colour match each other through strong cross-media patterns mediated by emotional association. This article presents the results of experiments evaluating people's emotions resulting from audio, images and lighting. The aim of this study is to design a system that can match different music with appropriate colours and lights.

The first part of the experiment has been done. Part of the results has been evaluated, showing the distribution of colours in CIELAB colour space corresponding to different physical characteristics (rhythm, pitch, tonality) of music. The results will be used in subsequent experiments.

The experiment was performed in a dark room with a computer screen. In the experiment, 13 songs were used, both classical and pop music were included. Each song had a 3-stage task. In order to ensure the stability of the results, 3 of the 13 songs were randomly selected and replayed. So, there were a total of 16 tasks. Each subject completed the task for 16 randomly ordered song samples. The subjects were university students including 14 women and 18 men, half of whom had a musical background.

Prior to the experiment, subjects were given an Ishihara colour vision test. They then took 1 minute to adapt to the environment. At the same time, an instruction was given on a calibrated display. They first listened to a piece of music for 1 minute, then the music will continue to repeat until they completed 3 tasks to describe the emotion of the song. The first task was colour selection. Each subject selected 5 colours from a colour palette (37 Munsell colours) which matched the emotion according of the song. In the second task, at least 3 adjectives describing their emotional response to the song were written down. Finally, 30 word-pairs needed to be answered. These described the emotion of the songs including the physical attributes such as high-low (pitch), fast-slow (rhythm), colour emotion terms (warm-cool, active-passive, heavy-light), and the music emotion terms (happy-sad, agitated-calm, strong-weak).

The initial factor analysis showed that there are 6 factors resulting from all the 30 perceptions. The top 3 factors were named 'Active', 'Agitated' and 'Like' respectively. The 'Active' factor included 'Happy' and 'Strong'. This in general agrees with the three factors found by previous studies. The 'Like' factor found here included 'harmonious' and 'attractive'. The colours that represent the 'like' factor included blues together with some more subtle shades. The other factors were associated with warm colours (strong red-yellow colours).

It was also found that the musical subjects were more sensitive to the colour corresponding to the tone, e.g. the colour of the major key is brighter and more colourful than those of the minor keys. This was not found from the non-musical subjects. For Chinese songs, most of the colours chosen by males were brighter than those selected by females.

### KEYWORDS

colour emotion | colour lighting | music cognition

## Understanding the use of Virtual Reality and Augmented Reality technology in the chromatic design of degenerated urban areas

Anamaria Rezende<sup>a\*</sup>, Clíce Mazzilli<sup>b</sup>

<sup>a</sup>University Anhembi Morumbi, São Paulo, Brazil

<sup>b</sup>University of São Paulo, São Paulo, Brazil

\*Corresponding author: ana.rezende@anhembibr

This article describes an investigation undergoing its initial phase, the study object of which is color as a means for expression of identity in public urban spaces. Moreover, the project aims to identify, understand and apprehend the ways in which the use of Virtual Reality (VR) and Augmented Reality (AR) technologies can contribute to chromatic environmental intervention researches and projects. Its initial premise is that the use of color can offer support to the reframing and reappropriation of local identity throughout the city's modification processes, particularly in decayed and unqualified urban areas.

Its theoretical and empirical bases are offered by bibliographical and iconographical research and case studies of creative Placemaking in Brazil and Latin America, in countries in which this kind of intervention already has a history and a legacy, in order to verify common results and regional characteristics and understand aspects of color as a universal language in successful cases. Furthermore, interviews will be conducted with the people responsible for the Placemaking actions in such noteworthy cases. Once the theoretical grounds and data have been established, the development of a project proposal for an action of creative and tacit Placemaking is expected, according to the following stages: 1) selection of a public space in a peripheral community of the city of São Paulo, Brazil; 2) creation of interactive initiatives with the community, in order to understand the local reality and identity; 3) structuring of a multidisciplinary team; 4) execution of the chromatic project.

For the development of the chromatic project per se, we will perform an iconographic survey of the place; organize color workshops together with the community; and, consequently, analyze the results in order to discuss the geography of color, the subjective colors and their corresponding meanings. Next, a chromatic palette that synthesizes these findings will be developed, as well as the project proposal for the Placemaking action in itself, and shared through the use of VR and AR technologies, so as to establish the efficiency, pertinence and costs of the proposed action.

Ultimately, we aim to elaborate basis for the development of a chromatic project that expresses local identity in Creative and Tacit Placemaking actions, that is, a method for identifying and analyzing color as an expression of identity in a public urban space. The purpose of choosing a poor and decayed suburban area of the city of São Paulo as the place for the intervention is attributing, or reestablishing, a sense of place and belonging, thus contributing to the materialization of identity. Technology will be used as a low-cost tool for virtually visualizing the results. Besides partnering with architects and designers, as well as researchers and professionals in the technology field, this project is also comprised of a theoretical broadening and an interchange with specialists in the field of creative Placemaking, as well as with national and international researchers with knowledge in the field of color in urban design. This article, in particular, relates how the RV and RA technologies will be utilized as a resource for the community and other participants to visualize the chromatic project, as well as its first results.

### KEYWORDS

color | urban design | identity | virtual reality | creative placemaking

## A Design Tool: Appearance simulator based on spectrum tunable LED lightings

Candong He<sup>a</sup>, Janlong Zhang<sup>a</sup>, Ronnier Luo<sup>b</sup>

<sup>a</sup>Thousand Lights Lighting (Changzhou) Limited, China

<sup>b</sup>Zhejiang University, China

\*Corresponding author: Candong.he@thouslite.com

The ability to be able to simulate the appearance of a product before its production is highly desirable. The appearance properties of a product together with its form and shape can be divided into colour, texture, gloss and translucency. These properties stimulate emotions in the product user and these complete the perception of product Total Appearance. An accurate and convincing simulation of appearance will greatly shorten the design cycle and reduce waste of materials. However, the success of the technology is to make the virtual product accurately simulate the appearance of the final product.

Typical tools used by designers are physical specifiers, such as Pantone, RAL, Munsell or NCS for colour specification. They are in the form of fan deck or booklet. However, these only consider the colour element but not the appearance attributes. There are two technologies on the market based on digital imaging technology: TAC<sup>®</sup> from Rite and DigiEye<sup>®</sup> from VeriVide.

The TAC<sup>®</sup> system includes three parts, a) a capturing device to scan the surface, b) a computer system to edit, manage, store the images, and c) a virtual booth to visualize the simulated 3D images on a display containing physical samples. This provides great realism but the cost is high. The DigiEye<sup>®</sup> system involves digital imaging to capture substrate appearance in terms of colour and texture. It can simulate the sample in different colours only in 2D.

An apparatus for surface simulation has been built. This applies two spectrum tunable LED systems to illuminate a surface substrate to produce a wide colour range. One LED system is used in a typical viewing cabinet with a grey background. This includes standard sources corresponding to CCTs of 6500, 5000, 4000, 2850K. There is a window in the wall and a substrate is placed behind the window. The substrate is illuminated by the second LED system to produce a wide colour gamut and the appearance of the product can be simulated. Designers can view the sample through the window.

The two lighting systems are accurately calibrated. The software controls the colour on the display and includes coarse and fine adjustments via a colour system such as CIELAB or Munsell, NCS system. The designed colour can be stored in different ways: reflectance, colorimetric values (XYZ or L\*a\*b\*) or calibrated image.

A number of observers performed colour matches using samples that included the 24 colours on the Macbeth Color Checker Chart. The results showed a good agreement between the matched and target colours. The mean colour difference from the mean (MCDM) value was 3.0 CIEDE2000. Simulations will be demonstrated using plastics, textiles with various textures.

# POSTERS SESSIONS

## SESSION 1

007 | 014 | 018 | 050 | 070 | 072 | 082 | 099 | 120 | 141 | 144

## SESSION 2

015 | 033 | 045 | 065 | 067 | 090 | 102 | 107 | 122 | 129 | 132

## SESSION 3

012 | 016 | 021 | 043 | 079 | 085 | 087 | 100 | 112 | 117 | 125 | 137 | 142

## SESSION 4

027 | 031 | 058 | 098 | 127 | 128

## SESSION 5

060 | 062 | 071 | 076 | 088 | 097 | 123 | 126 | 138



## Colors of a territory in a honey pot

Delphine Dejean<sup>a\*</sup>

<sup>a</sup>Univerty of Toulouse, LARA-SEPPIA EA4154 (UT2J)

\*Corresponding author: delphine.dejean@univ-tlse2.fr

Honey is a natural sweet commodity produced by bees that man has been transform into a food-processing activity by favouring lands being cultivated to set up hives. A typical and localised honey production highlights flavours and colours that bring out environmental characteristics. Thus, colour-design is used to consider colour as constituting the intellectual content and matter of them. Colour clues, perceived through optical or haptic vision, are likely to define the spatial and temporal interactions that lead to the formation of proactive localities in honey cultivation. When beekeeper creates a honey range, he defends his product as a witness to the biodiversity of his land. A syrupy or crystallised food, almost colourless or very brown, the chromaticity of honey alone sums up the process of collecting pollen from the flowers of the bee's foraging until it is transformed into nectar. The poetic metaphor about chromatic cultures contained in a honey pot goes beyond the importance of sampling and the production of a territorial image, since it is a question of rediscovering the floral and geographical origins by colours, whose traceability and taste education is today a strong social, economic and cultural heritage issue for many regions (chromatic heritage with high added value identified for the knowledge and local know-how)

How do chromatic cultures characterize a territory ? This slant at the origin of wider reflections is, like honey, a way to digest the landscape or at the origin of the landscape aesthetic itself. Isn't it so essential to no longer just provide communicating images to translate collective representations of localities. It's fundamental to undertake production of a colorama, a digital modeling tool that qualifies and valorizes the products coming from a territory and which is based on the functioning of chromatic cultures as well as the honey pot.

### KEYWORDS

colour design | chromatic cultures | geography of colour | colorama | terroir

## An experimental consideration of the perception of color and brightness for a point light source

Midori Tanaka\*, Minami Adachi, Takahiko Horiuchi

Chiba University, Japan

\*Corresponding author: midori@chiba-u.jp

Color perception can be affected by several factors, such as the surrounding environment and human vision characteristics. For example, it is well known that color and brightness perceptions change depending on the surrounding luminance conditions such as photopic, mesopic, and scotopic visions. Moreover, studies on color perception have been conducted under various conditions to consider the effects of the size of the viewing angle. However, how perception changes for a point light source with a minimum viewing angle is unknown.

In this study, we investigate the limits of perceived color and brightness for point light sources by conducting psychophysical experiments using human observers. This experimental investigation used colored point light sources (red, green, and blue) with different luminances displayed on an OLED display as experimental stimuli. Observers answered questions about the limit of their color and brightness perceptions in scotopic vision. Ten observers participated in the experiment. All were confirmed to have normal color vision using the Ishihara test. Each observer also demonstrated an averaged visual acuity—for both eyes—that was better than 20/20 vision. The viewing angle of the experimental stimuli was set as 1.0 minute by considering both the observer's visual acuity and the experimental environment because the viewing target had to be resolute by 20/20 vision. Two experiments were conducted.

Experiment A: The experimental stimuli consisted of a single colored point light source (red, green, or blue) that appeared with a gradual increase or decrease in luminance.

Experiment B: The experimental stimuli consisted of a colored point light source (red, green, or blue) paired with a monochromatic point light source, with the same luminance as the colored point light source. Both light sources appeared with a gradual increase or decrease in luminance.

Experimental results have shown that the color of a point light source can be perceived even in scotopic vision. This indicates that cones are partially working during scotopic vision. Our results from Experiment A indicated that the luminance of the perceptual limits differed depending on the color of the stimulus. Furthermore, we found that there were color stimuli whose perceived luminance limits were not equivalent for color and brightness. In Experiment B, we found that presentation of the paired light sources improved the stability of the observers' answers and reduced the incidence of misperception of color (e.g., the observers could not correctly perceive the color for the blue point light source in Experiment A). In contrast, the inter-variances for the green point light source, in both experiments, were significantly larger than those observed for other colors. Further consideration and investigations are needed to explore individual differences in color perception.

### KEYWORDS

color perception | point light source | scotopic vision

## Recent advances in production and uses of plant dyes from tropical africa

Adeola Victor Popoola<sup>a\*</sup>, IfeOluwa O. Daramola<sup>b</sup>,  
Solagbade Adepoju<sup>c</sup>

<sup>a\*</sup>Federal University of Technology, Akure

<sup>b</sup>Ajayi Crowther University, Oyo

<sup>c</sup>Corresponding author: avpopoola@futa.edu.ng

The coloring dye from Nigerian plant namely, *Harungana madagascariensis* was successfully isolated and characterized. The colorant was purified using chromatographic techniques. Its physico-chemical parameters were determined and attempt was made to elucidate its chemical structure. The R<sub>f</sub> value of the purified colorant was 0.96 and has absorption wavelength in the range of 407 to 575nm. The spectra analysis suggested that the colorant contained highly conjugated double bond together with the following functional groups: Amino –NH<sub>2</sub>, carbonyl =C=O and hydroxyl –OH groups. The dye, though fugitive absorbed very well onto cotton fibres with a steady dye uptake from the first dyeing minute to 30 minutes before attaining equilibrium dye uptake. The dye gave brilliant and appealing coloration to some home and industrial products.

### KEYWORDS

*harungana madagascariensis* | chromatography | equilibrium dyeing

## Visualising CMF processes for teaching colour in design

Maria Høgh-Mikkelsen

Design School Kolding, Denmark  
Corresponding author: mkm@dskd.dk

Design students, who specialise in designing colour and material strategies for product design, need knowledge of various design industry's processes to understand where and how they as colour and material designers can contribute to the process. This paper presents insights from an artistic research project that examines existing and possible design processes within Colour Material Finish Design (hereafter CMF) in a number of Danish companies. The aim of the project has been to create a series of visualisations of various processes that can be used in the teaching of design students as well as in forming the basis for a reflective discussion the field's currently only CMF process model by Becerra. CMF is a relatively new field in the design industry. It is also an undescribed field in design research. The only existing literature on CMF design processes at the present time is the book 'The Fundamental Principles of CMF Design' by Becerra 2016. Becerra describes a CMF process based on her own experiences from employment with Nokia and from her own company respectively. By creating visualizations and make a comparative analysis of the identified processes, this paper applies a critical view on the CMF design process and seek to clarify the need for a diversity of methods and processes.

The project works on a number of research questions: How can the CMF design process be investigated and challenged? What influencing factors, methods and processes can be identified in the work with CMF in companies? How can visualisations form the basis for critical reflection on different processes and methods? What skills and competencies should the future CMF design education strive to promote?

As a result of the increase in the teaching of colour and material at Design School Kolding, we see a growing interest in CMF jobs when students choose internships and future career paths. There is a need to identify more companies with design tasks within CMF. This project highlights a range of companies where designers can work with colour and material strategies. The project also identifies design methods, workflows and languages used in the companies. In the transformation from an experimental design student to professional designer, the student must be open to the tasks that may be added to the job of the colour and material designer. The project hypothesis is that companies work with colour and material selection in many ways; with different methods and workflows and at different levels depending on the type of company. For example, there may be influencing factors such as strategic decisions on product assortment, brand identity, corporate values, influences on trends, functional constraints, development of design concept, restrictions on production and more. Visualisations of the diversity of these processes will give the design student an understanding of her own role in the company and of the skills and competencies she should work with.

### KEYWORDS

CMF process | teaching | colour | design

## A general colour selection approach modelling by new research data of designers

Yun Chen<sup>a</sup>, Jianan Zhao<sup>b\*</sup>, Stephen Westland<sup>a</sup>

<sup>a</sup>University of Leeds, Leeds, United Kingdom

<sup>b</sup>Shanghai Jiao Tong University, Shanghai, China

\*Corresponding author: jzhao2@cca.edu

Although many design process studies and design theories were presented, in reality, designers have rarely followed standard rules (Bengtsson, 2013:89). A design process is a form of personal self-expression. The type of approach that designers use in their design work depends on their preference, experience and education background (Muratovski, 2015:2-3). Therefore, this work focused on the design process and colour selection understanding by collecting new research data from the designers and gathering the ideas from their design process to summarise a general colour selection method.

This work employs a semi-structured interview approach in a one-to-one interview format to investigate the process of design and collect their colour selection method. A total of twenty designers were interviewed from different design areas, working experience, age groups, cultural background and workplace around Korea, China, South Africa, Mexico and the United Kingdom. Ground Theory method and TF-IDF data analysis method were carried out in interview data analysis. A three-step approach was summarised in this study. Besides, several characteristics during the design and colour selection process were presented.

### KEYWORDS

colour choosing | design process | designer | approach

## Colour and Health

Michel Albert-Vanel<sup>a</sup>\*

<sup>a</sup>Honorary Professor at ENSAD, Paris

\*Corresponding author: albert-vanel@wanadoo.fr

Medical care through colour, which was once in its infancy, has found a major revival in the replacement of acupuncture needles with colour flashes, and other spectacular applications of light. So a new, more scientific medicine was born. And the results are very encouraging.

But to be even more effective, they must now be accompanied by what can be called the interior colour.

It is no longer a question of treating only the outside of the body by physical means, but much more of appealing the thought and will of the patient. It has been observed, in fact, that the action of the mind on matter is most effective, and most surely leads to healing. It also allows, as far as possible, to avoid drugs, because they are real poisons for the body.

We can thus make movements with the colours of the rainbow around the body. Or visualize more targeted colours, in a kind of active meditation, and bring them down to the spots where they can act usefully.

For the moment if it is not possible to ensure that you can heal all kinds of illnesses in this way, it does however allow you to keep yourself in good shape and in good health.

### KEYWORDS

colour | health | interior colour | mind | rainbow

## The differences in sensitivity for red with object color

Yasuyo G. Ichihara<sup>a</sup>, Takashi Sakamoto<sup>b</sup>

<sup>a</sup>Kogakuen University

<sup>b</sup>National Institute of Advanced Industrial Science and Technology

Generally, it is believed that color red is recognized as bright and sharp color. Since it symbolizes for fire and blood. However, for protan color vision people, color red appears as dark and dull color.

Few studies have examined differences in sensitivity for red with object color. So, in this research, I made various red color charts. This color chips were compared with the gray levels from white to black, and the subjects selected the same brightness. Subjects were divided into Ishihara plate test Pass, Protan, Protanomaly, Deutan, and Deuternomaly. Color vision by Ishihara plate, panel D-15 test, and anomaloscope. In addition, an impression survey was performed on each subject group using the SD method for various red color patches. The results showed a marked difference in the dull-sharp axis, indicating that subjects with Protan perceive the red color of Munsell 5R as a dark, dull color. Generally, it is believed that color red is recognized as bright and sharp color. Since it symbolizes for fire and blood. However for protan color vision people, color red appear as dark and dull color

### KEYWORDS

colour vision | color universal design | color vision defesiency

## Can you remember colour correctly?

Barbara Blaznik, Sabina Bračko\*

University of Ljubljana, Faculty of Natural Sciences and Engineering, Ljubljana, Slovenia

\*Corresponding author: sabina.bracko@ntf.uni-lj.si

Presenting author: Barbara Blaznik

Our study aimed to evaluate the long-term colour memory – the ability of the observer to remember the primary printing colours and the colours of some well-known symbols or brand logos.

Each observer was asked to select the remembered colour from a given set of colours, namely the Pantone colour system. Colour differences between the standard and selected colour were calculated and evaluated using the CIELAB colour space and the CIEDE2000 equation.

According to the results, the brand colours were remembered less accurately comparing to the primary printing colours. Blue colour tones were remembered less accurately in comparison to the red and yellow ones. The total colour difference was predominantly the consequence of the differences in chroma or hue. We can conclude that the colour, stored in our memory, significantly differs from the real colour. Nevertheless, no significant differences were found between the male and female observers.

### KEYWORDS

colour memory | colour perception | colour differences | CIEDE2000



## Effect of the size and shape of the measurement area on BRDF measurements on glossy samples

Ana Rabal, Guillaume Ged, Arnaud Richard, Gaël Obein\*

LNE-CNAM, La Plaine St Denis, France  
\*Corresponding author: gael.obein@lecnam.net

This work deals with optical measurements of the BRDF of real glossy surfaces, with a focus on the values in the specular area. It is composed by two studies: one is the measurement of the BRDF with variations of the size of the measurement area. The second is the measurement of the BRDF with modifications of the shape of the measurement area.

Both studies, size and shape, have been done on three glossiest samples of the commercial gloss scale provided by NCS. We used the black samples to avoid volume reflection from the surface of the material. The 60° specular gloss of these samples measured with a glossmeter are 95 gloss units, 75 gloss units and 50 gloss units.

We have used our goniospectrophotometer ConDOR (Conoscopic Device for Optical Reflectometry) for data acquisition. It is composed of a mobile illumination system embedded on a ring of 2 m of diameter, a 6-axis robot arm as a sample holder and a Fourier optic-based detection. Our system allows measuring in few seconds, the BRDF of the surface in 2 million of directions of observation, within a cone of  $\pm 1^\circ$  of the reflected space.

For the variation of the size of the measurement area, considering the scheme of the illumination system, we have modified the field diaphragm to achieve a measurement area from 10 mm diameter to 4 mm diameter with a step of 2 mm for each sample. The angular resolution of our measurement is 0.7°, due to the divergence of the illumination beam.

For the variation of the shape of the measurement area, we have changed the motif of the area of 10 mm diameter in the field diaphragm. The angular resolution is 0.14°. Three shapes have been tested: a disk, a ring and a cross. In this experiment, quantity of light is kept the same whatever is the shape, in order to avoid linearity and straylight corrections.

In both cases, size and shape, the BRDF of the three glossy samples have been measured in the specular area, with a zenithal angle of illumination of 30° from the normal. The behavior of the specular peak when carrying out these modifications has been studied.

Results in the first study show that the specular peak doesn't change when the size of the illuminated area varies, whatever the gloss of the sample is. At this moment, we are doing modifications in our facility to reach submillimeter illumination sizes.

Results in the second study show modifications of shape of the specular peak for each sample when the shape of the illumination area varies. The glossier the sample, the more differences we have found between motifs in the central area of the specular peak.

### KEYWORDS

BRDF | gloss | specular peak | goniospectrophotometer

## Beside the stones: a landscape among forgotten colours

Verónica Conte<sup>a</sup>\*

<sup>a</sup>CIAUD – Research Centre for Architecture, Urbanism and Design, Lisbon School of Architecture, University of Lisbon, Portugal

\*Corresponding author: conte.veronica@gmail.com

Pursuing an image of local uniqueness – a trend which has followed the emergence of tourism and the consolidation of the concept of landscape associated with it (Conte, 2019; Gianni & d'Angelo, 1999) – some rural areas, especially in Europe (Renaud, 2016) have been reinforcing architectural features in the constructions and recoveries of the built heritage which are not always accompanied by credible discourses around the reproduction of vernacular techniques. Such constructions often impose an image of the place which gradually comes to be recognized by the community in general.

In praising diverse and complex narratives for the history of a place, the intention, based on a concrete example, is to reflect on the following question: how to bring to light the disappearing chromatic building-features – which are victims of ignorance about the conceptual origin of the image that it is being forged – while the place's history and other constructive possibilities are being devalued and forgotten, hand in hand with current building techniques which are erasing their traces.

Carrazedo, a village deep in the Serra da Nogueira (Trás-os-Montes, Portugal), is the chosen case study. An artistic-ethnographic research, between 2008-2020, was carried out using interviews of inhabitants (residents and ex-residents) and an exhaustive photographic chromatic survey (only photography was used because the colours are tainted by time, and its exact reproduction makes no sense). Data collection focused on changing and transition, both of colour and narratives about the landscape by those who produced it before the village became a tourism niche.

In Carrazedo, as in neighbouring villages, the “truth to materials” is promoted today (by evident descent from Ruskin's thought, 1849). The stone is the only colour on the façades, as plasters of the more affluent houses have been removed (which, when existing, were whitewashed or painted in white); and the wood colour of individual elements is favoured. This scenario covers the village's houses in similar tones, with only a few reds and whites from aluminium frames standing out.

The colours collected by the survey mainly correspond to the painted frames of doors and windows of houses remaining from the 1970s after the rural exodus. From an immaterial perspective, these careless, faded colours denounce the «dépaysement» of those who are gone and the abandonment of a landscape. Trying to build a narrative from this event, the inhabitants were asked about what they saw, what they currently see, and what they would like to see from their doors and windows. The colour and the stories – interconnected by the metaphor of the passage of time – make visible the temporal distance and a complex narrative of the place, composed of people, landscape and colours.

Thus, through images and fragments of discourse (medium), the fragility and questioned truth of the concept for the contemporary dominant image of the place is evinced, and a more organic and diverse practice for its shaping is presented. A wide chromatic possibility for the individual elements of the built environment is another result obtained from the research.

### KEYWORDS

colour | narrative of a place | cultural heritage | Portugal

## Effects of LED lighting color on work efficiency and alertness

Kosuke Wakabayashi, Hiroshi Takahashi\*

Kanagawa Institute of Technology, Atsugi, Japan  
\*Corresponding author: htakahashi@ele.kanagawa-it.ac.jp

Light-emitting diodes (LEDs) were first developed in 1962, but it wasn't until 1989 that blue LEDs were developed, enabling access to the full range of visible light. Light color is closely related to living organisms, and in particular, fish. It has been reported that rapid changes in the color and pattern on the body of fish are triggered by light absorbing and reflecting chromatophores in the skin. However, the exact relationship between light color and other living organisms, such as humans, remains unclear. The present study investigates how work efficiency and alertness levels can be affected by light color. The work surface illuminance was set to 400 lx and white (W), red (R), green (G), blue (B), yellow (Y), cyan (C) and magenta (M), lights were used. Test subjects were asked to perform three different tasks: a calculation task, a concentration task, and a creative task. The calculation task comprised of a simple mathematics test. The concentration task comprised of threading a needle. The creative task comprised of a clue association test. In this test, the subject was given a topic, and was asked to generate as many related ideas as possible within the span of 5 min. Each task was carried out after the subjects were given 25 min to adapt to each lighting condition. Electroencephalogram (EEG) data were recorded from the test subjects throughout the experiments. Data were grouped into the following two frequency ranges: 8-12.5 Hz (alpha) and 13-30 Hz (beta). The beta/alpha ratio was used as an index of alertness level. The alertness levels were higher during all task periods than during the adaptation period. When comparing the results for white and chromatic light, alertness levels were found to be higher under chromatic light, except for cyan, and green during the concentration task period. The results suggest that chromatic light produces a higher work efficiency than white light. For the creative task, work efficiency under yellow light was found to increase the most. In addition, a positive or negative correlation between the alertness level and the work efficiency was found depending on the content of the work.

### KEYWORDS

lighting color | LED | work efficiency | alertness

## A contribution of on-site spectroradiometric analysis to the study of prehistoric cave art: the case of Points cave (Aiguèze, Gard, France)

D. Lafon-Pham<sup>a</sup>, S. Konik<sup>b</sup>, J. Monney<sup>c</sup>

<sup>a</sup>EuroMov Digital Health in Motion, Univ. Montpellier, IMT Mines Ales, Alès, France

<sup>b</sup>Ministère de la Culture / Sous-direction de l'Archéologie / Centre National de la Préhistoire et UMR 5199 - PACEA, Périgueux, France

<sup>c</sup>Laboratoire EDYTEM - Université de Savoie, CNRS, Chambéry, France

\*Corresponding author: dominique.lafon@mines-ales.fr

Points cave (Aiguèze; Gard; France) is located in the middle of the Ardèche river gorges, not far from Chauvet cave. This cave contains rock art attributed to the Upper Palaeolithic. Its walls show 72 rock paintings and drawings distributed in spatially distinct subsets: 5 animal figures, 5 indeterminate lines, 2 bilobed signs, 1 angular sign and 4 clusters of punctuation marks (made by coloring the palm with colored matter and applying it as a stamp to the cave wall). The present work addresses the in situ study of the Palaeolithic rock art colors. It is part of a multidisciplinary research project studying the cave since 2011. The vast majority of the coloring matter used for the drawings is red. By considering the rock art's color on a purely visual point of view, two color subsets appear: purplish red and beige red. An in situ radiometric measurement campaign was carried out to obtain objective data regarding the colors of the rock art and its spatial distribution. Our aim was to obtain objective quantified color information in order to complete the already existing archaeological analysis and interpretation about the spatial organization of the rock art. Color quantification allows an objective inter-comparison not only between the different rock paintings and drawings of the cave, but also with rock art measured in other caves.

Measurements in the visible range were carried out, using a spectroradiometer (CS2000-Konica Minolta). This fieldwork had been done in compliance with the preservation rules (contactless). The measuring angles and distances were adapted on a case by case basis according to the characteristics of the painted surface to be measured. The accessibility of each measured area and its state of preservation i.e. ability of the colored matter in its actual state to hide the rock surface were taken into account. A lighting system spectrum with a spectral power distribution close to the standard illuminant D50 was used. We were thus able to record the entire optical behavior of all the paintings and drawings (around 150 measurement points). A precise survey of each measured zone allowed us to record its state of preservation: The main information concerns the more or less good covering of the rocky support by the coloring matter applied by the Paleolithic artists as well as the possible presence of calcite, either in the form of more or less translucent veils, or in the form of opaque concretions of very small sizes. The known data about the drawing technics employed by the Paleolithic artist(s) were also considered.

Analyses carried out on the spectral measurements aimed to answer one question. What are the color criteria allowing to compare different rock paintings and drawings, taking into account their proper surface's states (impact of the different technics of application and/or state of preservation on the measured values)? We were thus able to establish and/or confirm the existence of different clusters of graphic entities on the base of identified causalities which fall under:

- The nature of the coloring matters, and the influence of theirs mineralogical compositions
- The state of the coloring matters on the rock walls.

These elements contribute to a more in-depth understanding of the chronocultural consistence of the iconographic project.

### KEYWORDS

*natural coloring matter | palaeolithic rock art | spectrophotometry*

## Comparison of Environmental Landscape Color Harmony Strategies between Keelung ZhengBin Finishing Port and Dongyin Nanao Villages Color Schemes

Yuh-Chang Wei<sup>a\*</sup>, Monica Kuo<sup>b</sup>, Yen-Ching Tseng<sup>c</sup>, Wei Wang<sup>d</sup>

<sup>abcd</sup> Chinese Culture University, Taipei, Taiwan

\*Corresponding author: ycwei@faculty.pccu.edu.tw

The concept of environmental landscape color harmony is highly dependent on the balance among nurture environment, urban landscape and local culture. The aim of this study is to compare environmental landscape color harmony strategies between Keelung Zheng-Bin Finishing Port and Dongyin Nanao Villages color schemes in order to better understand how a suitable color plan to be determined. Both of color schemes are, based on Jean-Philippe Lenclos's methodology of color geography, to adopt NCS environmental color survey tool for the regional local colors investigation and to develop a color planning strategy. The objective of both color schemes is to maintain the color imagery of local environment, to achieve "colorful diversity", and to develop a proper color scheme to enhance regional characteristics and cultural style.

A scientific NCS environmental color survey conducted to collect regional colors information and to establish an environmental color database for both projects as well. A subjective environmental color analysis evaluated by the color planner helped to design a color scheme, based on the color harmony strategy. The color planner designed a color scheme by determining domain colors and color contrast in compliance with proper lightness, chroma, environment context, and color composition to fulfill the objective of harmony. However, the color harmony strategies between two color schemes found quite different. An in-depth analysis conducted to compare both color plans with a systematic process.

The results of the study have indicated as follow:

1. The environmental landscape color scheme is a complex and comprehensive work. The analysis of landscape and urban environmental colors needs a multi-dimensional viewpoint along with a scientifically systematic process to investigate the overall appearance and characteristics of the geographical region objectively. A good color planning strategy must look into both the macro and micro levels, including nature environment color, urban landscape color and local humanistic color, etc.
2. The environmental landscape color harmony is required to maintain continuity and order with adjacent colors, to keep color harmony with the surround spatial environment, and to utilize the regional landscape characteristics in accordance with background architectural colors.
3. The environmental landscape color scheme contains the strong publicity. The approval of both projects is according to the collaborative discussions among stakeholders, experts, scholars and the color planner. However, the residents' culture heritage and color preferences proved to be the significant factors influencing the outcome of color scheme. It is crucial to obtain the color consensus between the stakeholders and color planner that requires a great deal of efforts.

### KEYWORDS

color scheme | NCS environmental color survey | color harmony strategy | culture heritage | color preference

## Evaluation and control of the properties and mutations of the pictorial visible

Etienne Trouvers<sup>a\*</sup>, Laurence Tardy<sup>b</sup>, Jean-Marc Steyaert<sup>c\*</sup>

<sup>a</sup>Artist, painter using natural colors and digital colors, ENSBA

<sup>b</sup>Historian of art, teacher at Ecole du Louvre

<sup>c</sup>Ecole Polytechnique Senior Professor

\*Corresponding authors:contact@etienne-trouvers.com, steyaert@lix.polytechnique.fr

The goal is to elaborate a digital visual approach to paintings, structured and coherent, which would allow to express their palette harmonies of colors, to recover them in case of deterioration and to propose virtual restorations. The concrete outputs are pedagogical materials for digital communication, printing tools integrating pigment hues perception, in 2D to start, then in 3D.

Furthermore, experts and practitioners of artistic legacy could appreciate to use a digital expert system dedicated to the comparative and evolutionary analysis of pictorial and graphic masterpieces.

This experimental system allows a comprehensive reading of the harmonies of work of art: search and identification of shapes, drawings, intensities and colors. On this basis of primitives, we aim at building a set of software tools able to perform comparative and differential analyses of states before/after restauration, after various damages or natural time decay for instance, but also able to modify an original on the basis of real, reported or even imaginary data... These situations contribute to put in light very deep plastic properties - visual and differential - of the works in an approach both resultant and prospective.

Up to now the rationale for restorations is mainly based upon the stratigraphic study which «allows to determine the nature and the sickness of the successive paint layers» or upon a sample. We are thus limited to the unknown/unseen supposed original of the work to make crucial - possibly wrong - choices of restoration. In particular, this type of purely physical and chemical analysis does not offer the possibility to fully considerate global process of elaboration and its subtle formal shades: i.e. a pictorial project with its glaze, varnish - colorless or warm, with autograph finish touches, subtle touch-ups by a doubtful author as often the best artists proceed in their search of absolute, and even pentimenti - sometimes surprising - or posterior overpaints hardly understood.

For instance, how to understand the meaningful attitude of the butler in Veronese's *The Weeding at Cana*? A case study whose successive steps have to be deciphered: a sophisticated green dress with shot-silk moiré effects, obtained maybe by pouncing then grey mastic and varnish filling, before the figure is dressed in a sleeveless caftan, a patch of brick red muted color with an adequate binder and gaze mixed with the golden varnish? Another example in Courbet's *L'Atelier du peintre*: how to perceive and understand the essential need of central landscape in the global spatial system of his huge work, as well as some other complex formal features of *L'Atelier*? Such situations illustrate the most interest to have an elaborate tool for the interpretation, the analysis and the virtual and visual renderings.

As a matter of fact, we aim to revitalize the critical mind of one who scrutinizes and questions the objective differences of the visible in order to deter and catch the aesthetic subtleties not only accordingly to the present norm and taste or fashion, but also with tolerance and scope of view; therefore having in mind what mankind memory remains can teach us through Fine Arts.

### KEYWORDS

visual approach | color | digital restoration | comparative system

## Effect of painting treatment on color change considering cellular structure inside of wood

Kazushi Ohshima<sup>a\*</sup>, Hiroyuki Sugimoto<sup>a</sup>,  
Masatoshi Sugimori<sup>a</sup>, Emika Sawada<sup>b</sup>

<sup>a</sup>Ehime-University Graduate School of Agriculture, Matsuyama, Japan.

<sup>b</sup>Ehime-University, Matsuyama, Japan.

\*Corresponding author: kazushi3150@gmail.com

The growing interest in environmental issues has led to an expansion of design applications that take advantage of the appearance of wood. Painting treatment is applied with permeable, transparent paints because improvement in appearance and durability is required for these purposes. However, the mechanism of the change in appearance caused by such a painting treatment has not been clarified, and this is a major factor that hinders designable industrial use of wood. Recently, however, the presenters found from light transmission experiments in cedar with different compressibility that light reflection and transmission at the interface between the lumen and cell wall, which have different refractive indices, are related to the brightness of the wood. The reflectance of light at one interface is determined by the difference in the refractive indices of the two materials that make up the interface, according to Fresnel's formula. Therefore, it is thought that the amount of paint penetration affects the mechanism of appearance change in the painting treatment that makes use of the design of the wood.

Therefore, this research aims to clarify the mechanism of change in total reflectance and total transmittance of visible light due to painting treatment, X-ray CT observations of the internal structure of the material and measurement of the optical properties of visible light with a spectrophotometer were performed on two types of grain of hinoki cypress with various amounts of paint.

In the observation of CT image, the penetration of the paint into the material was not confirmed in the edge-grain samples, whereas that was confirmed in the end-grain samples. In addition, the permeability of the paint of the end-grain samples were quantified, those were in a positively correlated with the paint amount. In the optical characteristics measurement, the longer wavelength, the value of the total transmittance is larger, and the value of the total reflectance was affected by the increase in the value of the total transmittance, due to the interface change caused by the penetration of the paint into the lumen.

In the middle to long wavelength region, the value of total reflectance decreased and the value of total transmittance increased with an increase in the amount of permeation.

These results suggest that the mechanism of lightness reduction by the clear painting treatment is strongly related to the increase in the value of the total transmittance in the medium to long wavelength region due to the difference in the amount of penetration of the paint. On the other hand, at short wavelengths, the effect of absorption was greater. Therefore, the wavelength dependence of the reflectance change due to painting treatment may dominate the color change due to painting treatment. The present study could be effectively used to adjust the brightness of veneer when it is used for automotive interiors and flooring.

### KEYWORDS

painting treatment | color change | interface | transmittance | reflectance

## The Impact of Individual Observer Color Matching Functions on Simulated Texture Features

Yuan Tian\*, Jean-Baptiste Thomas, Fereshteh Mirjalili

Department of Computer Science, Norwegian University of Science and Technology, Gjøvik, Norway  
\*Corresponding author: yuanti@stud.ntnu.no

We investigated the impact of individual observer color matching functions (CMF) on simulated texture features. Our hypothesis is that most people perceive texture in a similar manner, thus a texture indicator that is least dependent on human individual vision would be most likely a potential fit to visually perceived texture. To this end, the following strategy was implemented: Hyper-spectral images were converted into XYZ images for individual observer CMFs, estimated by an individual observer colorimetric model. Contrast sensitivity function (CSF) filtering was applied to the XYZ images for visual simulation. The texture features were extracted from the filtered images. Finally, the difference between the texture features computed for each observer were analyzed.

We used the HyTexiLa reflectance image dataset by Khan et al. [1], that includes 112 images of four material classes, namely textile, wood, stone and food, covering a wavelength range from 400 to 1000 nm with 3.19 nm intervals. The individual observer CMFs were generated using the color vision model proposed by Asano et al. [2]. Their dataset includes 151 individual CMFs obtained as a result of a series of color matching experiments performed by 151 color-normal observers. The proposed model predicts individual cone fundamental, lms-CMF, as a function of person's age and some physiological parameters such as lens and macular pigment density. Each Individual lms-CMF was converted into the corresponding xyz-CMF by a linear transform obtained from a linear regression between the CIE 1964 standard colorimetric observer and the average lms-CMFs. The reflectance images were subsequently converted into XYZ images using the obtained xyz-CMFs.

To perform CSF filtering following the method proposed by Pedersen and Farup [3], the reflectance images were first converted into individual observer XYZ images using the obtained individual xyz-CMFs. The XYZ images were then converted into RGB images by linear transformation. The individual RGB images were finally converted into the corresponding individual observer YCbCr images using a specific set of RGB stimulus. The variability of the CMFs between individual observers is assumed to be maintained in the YCbCr color space. Finally, the contrast masking was applied on the YCbCr images to simulate the viewing distances of approximately 0.5 and 2 meters.

Two methods to compute texture features are implemented, one method to extract texture features from Y channel, and the other from all three channels of the individual observer YCbCr CSF filtered images. In order to test the hypothesis, a comparison of the texture features is implemented between two observer groups, one with lower RMSE in CMFs from the average observer, and the other with higher RMSE in CMFs. In texture feature hyperspaces, the volume ratio between the two groups' feature vector clouds indicates how individual observers have similar texture features.

[1] H. A. Khan, S. Mihoubi, B. Mathon, J. B. Thomas, and J. Y. Hardeberg, "HyTexiLa: High resolution visible and near infrared hyperspectral texture images," *Sensors*, vol. 18, no. 7, pp. 1–30, 2018.

[2] Y. Asano, M. D. Fairchild, and L. Blondé, "Individual colorimetric observer model," *PLoS One*, vol. 11, no. 2, pp. 1–19, 2016.

[3] M. Pedersen and I. Farup, "Simulation of image detail visibility using contrast sensitivity functions and wavelets," *Proc. - IS&T/SID Color Imaging Conf.*, pp. 70–75, 2012.

### KEYWORDS

texture features | color matching functions | hyper-spectral images



## The narrative pattern: a creative gesture in children's book illustrations through natural and digital colours

Camille Landreau<sup>a\*</sup>

<sup>a</sup>LARA-SEPPIA, Allph@, University Toulouse Jean Jaures, UT2J, Toulouse, France.

\*Corresponding author: camille.landreau@univ-tlse2.fr

“A colour is never neutral; it always reflects an impression, a persistent image. A colour is never total, never fixed; it is mutable, elusive, perceived differently depending on the other colours around it, the nature of the light that renders it visible, the eye of the beholder: Colours, like words, are always fleeting.” (Verner Panton, Notes on Colour, Danish Design Center, 1991).

Combining research and creation, the reflection carried out throughout my thesis, Poietic of colouring: from the gleaning in design to the creative experience of the pattern in illustration, takes place in a dialogue between researches that results in the gleaning of heteroclitic plastic elements, experimentations where the development of chromatic experiments is discussed in the workshop-laboratory and project oriented towards the colouring of the pattern in illustration.

The common thread is the establishment and questioning of working methods, to offer experiments to poetize and reconsider the very form of modelling. The development of exploratory processes thus allows a reflection between theoretical thought and artistic practice.

In my PhD, my research field is illustrated children's book and the tale. The purpose is to explore in depth the chromatic perceptions of illustrations, to question the creative process and the artistic technique. As for, I set up a methodology in my workshop-laboratory that leads me to analyse images, create moodboards, lexical fields, experiment colours, classify them through colour charts, chromatic and sensory cartographies, to design narrative patterns and a colour lexicon of children book.

As an illustrator, colourist, designer, the use of colours, in its multiple ways, is very important and is a real added value. I make of the colour a principle of the composition in the illustration. I see a connection in my work between natural and digital colours: narrative materials which show the exploration of the creation of a mixed media illustration. I create plastic variations through the techniques of hand drawn patterns, digital and manual colouring, embroidery, collage, tincture... I find those combinations, interesting and magnify the sensitive experience and the creative gesture. The passage from the drawing “the illustrated line” to a textile experiment “the embroidered thread”. Colour thus obtains its own dialectic around a materiality a “visual writing”, the process of storytelling and a new aesthetic language. As Sonia Delaunay said in her diary: “The colour became a vital way of expression, as the power of speech. I play with colours like a new way of expression(..).”

As we will be able to see, through a methodical and sensitive study, it's to understand the stakes of illustration and their importance in our visual culture as well as in their teaching. It develops a manufacture of ways of seeing and undertaking this particular mode of expression.

### KEYWORDS

pattern | colouring | illustration | design project | children book

## Colour, Human experience and cyborgism

Valérie Bonnardel

University of Winchester, Winchester, United Kingdom  
Valerie.bonnardel@winchester.ac.uk

In their book «The embodied mind: cognitive science and human experience» published in 1993, Francisco Varela, Evan Thompson and Eleanor Rosch propose a new conception of cognition qualified as active <sup>[1]</sup>. In an enactive view of cognition living organisms are autonomous systems (endowed with self-organization) generating meaning which gives rise to the co-determined origin of cognition and environment. Thus, enaction attempts to reconcile traditional oppositions (subject-object, body-mind, self-others, etc.) and, in so doing, offers a way intermediary between the opposition «computational objectivism» and «neurophysiological subjectivism».

To illustrate an enactive view of cognition, the authors choose the example of colored vision which has the advantage of being, both, a transdisciplinary subject, including among others, biology, psychology, anthropology and artistic disciplines and which has an immediately meaningful human experience in terms of perception, cognition and emotion. In the domain of colour vision, objectivism struggles to account for the colored experience because there is no simple and unequivocal causal relationship between the physical signal (luminous flux) reaching the eye and the color perceived. As for subjectivism, it fails to account for universally shared aspects of color vision such as their categorical perception. The enactive approach reconciles these two aspects; cognition is «embodied» and results from experiences made possible with a body endowed with sensorimotor capacities which are exerted in a physical, biological, psychological, social and cultural environment from which experience emerges (enaction) and where perception and action are inseparable. The quality of the enacted experience of the colorful appearance then results from the structural coupling between the organism and its environment for which the intersubjectivity and the cultural sharing of this experience are essential to the extraction of its meaning.

### KEYWORDS

colour perception | embodied cognition | enaction.

## Colour out of place: Extinction explored through art practice

Yulia Kovanova

Edinburgh College of Art, The University of Edinburgh  
yulia.kovanova@ed.ac.uk

This paper proposes the concept of colour 'extinction' as a way to think through the current ecological situation, specifically the sixth mass extinction provoked by human action. This is explored through the framework of the emerging field of multispecies studies, with particular focus on the concept of 'entanglements', as defined within the wider field of Environmental Humanities, in conjunction with contemporary art practice. The author submits that art practice is a powerful tool through which to approach extinction, as it invites us to tap into an emotional connection. Colour, in particular, offers a sensorial entry into an environment, and a way to observe the presence or absence of species.

It may seem as though, if certain colours and colour combinations are lost from our environment, through the disappearance of plant and animal species, we can preserve those colours through digital images. However, the physical loss will change the collective experience of our environment completely. The combination of colours in a natural landscape is a sign of its health. If that colour balance is disturbed, the health of the landscape and its interconnected livelihoods will be affected.

As with any digital representation or record, every colour is an approximation. Colour in the natural landscape is a constantly shifting phenomenon - through seasons, times of the day, and the course of evolution - this is an experience that digital mimicry would struggle to precisely replicate. The issues of natural and digital colour are discussed alongside the idea of a nature/culture divide, as highlighted by various authors in the Environmental Humanities.

The author proposes conveying extinction and its subsequent losses through a series of artworks. It is then argued that art practice is a powerful tool to help visualise these issues. Colour studies offer theories that can feed into ecological thinking, and multispecies studies offers a strong interdisciplinary platform.

### KEYWORDS

art | colour | ecology | extinction | loss | multispecies studies

## Assessing illumination diffuseness in light booths with a log chroma histogram

Siddhant Sahu, Jean Baptiste Thomas\*,  
Jon Yngve Hardeberg

The Norwegian Colour and Visual Computing Lab, Department of Computer Science,  
Norwegian University of Science and Technology  
\*Corresponding author: jean.b.thomas@ntnu.no

Controlled lighting is a key part of color quality control and primarily in the painting industry wherein the finish of the product is tested under a controlled lighting. For this purpose light booths are used, which is an apparatus that simulates different canonical lighting conditions in the most diffused form minimizing the cast of harsh shadows. This helps in examining accurately how the product appears under these lighting conditions independent of environmental influences. However, we noticed a discrepancy between the quality of diffuseness between different illuminants of the light booth. More specifically, the illuminants like “D50” and “D65” were more diffused as compared to the “F” illuminant.

Therefore, in order to show these differences quantitatively, we proposed a methodology in this work. At first we acquired a scene in a light booth with several illuminations and investigated a particular type of histogram called as the “Log-Chroma Histogram”. From R, G and B values two chrominance measures were defined and the histogram was plotted for these chrominance values in the scene. Then we fit a two dimensional Gaussian distribution to the histogram. The parameters of the distribution, more specifically the standard deviation which revealed that indeed the diffuseness quality between the illuminants were different. This observation helps us to potentially rank the illumination by diffuseness on comparing the histograms.

Furthermore, we also observed that when the illumination creates harsh shadows, or in other words, the illumination is not well diffused, the corresponding histogram is asymmetrically distributed or skewed. Considering this we also propose skewness as a metric to rank illuminant’s diffuseness on this particular histogram. We suspect this is due to the cast of harsh shadows, hence we have also developed a MATLAB app which corresponds a given pixel’s chrominance to its histogram values. We also make the image dataset used for the analysis publicly available at [www.colourlab.no/cid](http://www.colourlab.no/cid).

### KEYWORDS

*diffuseness | light booth | log chroma histogram*

## The Highlight effect in structural color from cellulose nanocrystals

Noora E. Yau<sup>a\*</sup>, Konrad W. Klockars<sup>b</sup>, Blaise L. Tardy<sup>c</sup>,  
Orlando J. Rojas<sup>a</sup>

<sup>a</sup>Department of Design, School of Arts, Design and Architecture, Aalto University, FI-00076 Aalto, Finland

<sup>b</sup>Department of Bioproducts and Biosystems, School of Chemical Engineering, Aalto University, 00076 Aalto, Finland

<sup>c</sup>Department of Chemical & Biological Engineering, Vancouver Campus, University of British Columbia, 2360 East Mall, Vancouver

\*Corresponding author: noora.yau@aalto.fi

When new materials are launched, producers tend to focus on the functional properties. However, functionality alone may not guarantee the commercial success of new materials. For this reason, materials science and industry often turn to designers, who they hope will develop both the experiential and functional properties of the material.

Materials used in product design must meet the functional and esthetic needs of the consumer, meaning that the material must function in its technical context, but also on an emotional level: to captivate people's attention and appreciation, to make sense. Material design researchers have argued that the materials development process should not focus solely on the functionality of the material but also consider other aspects. It has been suggested to not only consider questions like "what is this material?", but also questions like what this material does, what it expresses to us, what it elicits from us, and what it makes us do. The purpose of this is to try to bring understanding not only to the functional qualities of the material, but also to the experience or a feeling involved; to create a holistic, meaningful user experience. This work addresses a material development case, where both the technical and design perspective has been important and needed.

Structural color arising from nanostructures of cellulose nanocrystals has been studied for some time already. However, well-founded practical applications of these visually enchanting colors have not been realized yet. The focus in the development of nanocellulose-based structural colors has been on advanced materials applications, for example tunable reflective filters or various sensors. In contrast, our research aims to bring nanocellulose-based structural color into the field of design and art. There is a great need for eco-structural colors, as iridescent and glittering effect colors are commonly used in design and art. However, these colors are currently produced using environmentally harmful materials and toxic pigments.

Materials may have properties that seem irrelevant or insignificant for technical applications. However, the same feature may be of great visual interest in design. As an example, cellulose nanocrystals give rise to the so-called coffee ring effect when they assemble into the nanostructure responsible for the structural color. The effect refers to a rainbow-like border-color appearing on dry films. Scientists have generally considered this effect a problem to be solved, since it prevents films of uniform color. However, the same phenomenon could create visually and esthetically appealing effects. In the design and art field this effect could be used as a "highlight -effect", since it can bring up the shapes and forms of the colored area. CNCs do this naturally, and as far as we know, no other coloring method can achieve this.

For material development and commercialization, it is crucial to investigate how to achieve uniform colors from nanocellulose. This achievement would greatly expand the possibilities of using these colors. At the same time, the highlight effect could also be one of the competitive advantages of the material. Border colors could, for example, emphasize the shape of objects and be used for pattern design.

### KEYWORDS

structural color | cellulose nanocrystals | coffee-ring effect | design | multidisciplinary

## Visual appearance of wood materials under various lighting colour conditions

Sae Miyata<sup>a\*</sup>, Shino Okuda<sup>b</sup>

<sup>a</sup>Graduate School of Doshisha Women's College, Kyoto, Japan

<sup>b</sup>Doshisha Women's College of Liberal Arts, Kyoto, Japan

\*Corresponding author: id19001@dwc.doshisha.ac.jp

There are many kinds of interior wood materials and their colour appearance and visual texture are influenced by lighting conditions. This study aims to clarify the visual texture of wood materials under various lighting conditions.

We conducted the subjective experiment using twelve kinds of wood materials, Japanese cedar, Japanese cypress, chestnut, white oak, beech, teak, Chinese quince, walnut, rose wood, pine, maple, and black cherry. Each size of wood plate is 100 mm (width), 80 mm (depth), and 4 mm (thickness). These were presented in a space of 600 mm (width), 450 mm (depth) and 500 mm (height). This space was some objects in different colours and the inside walls were white. A LED light source [LEDCube, THOUSLITE] which has 15 channels of LED spectra (from 365 nm to 670 nm peak) and could control spectral distribution was equipped on the top of the space. Next, 24 kinds of lighting conditions were set with four levels of CCT (3300 K, 4000 K, 5000 K 6500 K), three kinds of duv (-0.01, -0.005, 0) and two saturation levels of red colour.

Participants observed each wood plate and evaluated four items, 'cold - warm', 'rough - smooth', 'dry - wet', and 'hard - soft' with a seven-steps scale. They also rated the naturalness of color appearance and the preference of lighting with a numerical scale from -3 to +3. Female university students participated in this experiment voluntarily, and they were in all twenties and have normal colour vision.

According to the results, the evaluations of the naturalness of colour appearance and the preference of lighting were good under the lighting in 4000 K and 5000 K, negative duv and including long wavelength. Also, it was revealed that the lighting conditions in 3000 K and 4000 K made wood materials look softer and warmer than the lighting in 5000 K and 6500 K. Moreover, the evaluations of the naturalness of colour appearance and the preference of lighting have strong positive correlation.

In conclusion, the lighting in 4000 K and 5000 K, negative duv and including long wavelength is preferred wood materials. Also, increase or decrease of chroma saturation of red colour affects visual texture and colour appearance of them. Therefore, light colour affects visual appearance of wood materials.

### KEYWORDS

visual texture | wood material | light colour

## The importance of the semiotic development of a color chart in a fashion collection

Ítalo José de Medeiros Dantas<sup>a\*</sup>,  
Camila Assis Peres Silva<sup>a</sup>

<sup>a</sup>Federal University of Campina Grande, Campina Grande, Paraíba, Brazil  
\*Corresponding author: italodantasdesign@hotmail.com

Color perception is a coordinated system that combines psychological, physiological, physical, sensory and cultural perceptions of the human mind's cognition and interpretation. Therefore, the symbology and the semantic dimension of colors propose a series of meanings based on the perceptions of individuals, as well as through experiments that identify the effects caused by them on human cognition. Through social conventions historically passed down through generations, are known most of the senses that are projected in colors today. In fashion collections, these chromatic symbols are used both to shape the concept that guides the theme of the work and to attract the target audience of the segment. It converges a lot with the notion that in the fashion design collections we work with a color chart with a greater number of possibilities that will bring with it the narrative power of delineating new chromatic information and creating its own signs and signifiers.

Thus, it is seen that the symbology linked to colors within social conventions no longer translate as a usual reality, so that in the case of collections with a commercial bias, working on cohesion and coherence between the target group's cultural baggage, the collection theme, fashion trends, market trends, and finally, the chromatic representation for identification purposes, becomes an important and complex task. Generalized methodologies of chromatic usability tend not to be satisfactorily applicable to all cases in fashion design, making necessary increasingly specific and innovative approaches, centered on the user's perception. Therefore, the levels of difficulty are located on how to develop the elements of the design in order to produce the symbolic effects designed, from this context, exploring methods present in other sciences is a promising and consequently innovative way to discover new ways of solving problems; with that thought, one finds semiotic theories.

With this, the present article aims to explore the level of importance that the semiotic construction of a color chart plays within the final result of the visual communication of a fashion collection when it's related to the development of the proposed concept. To this end, the research is classified as exploratory-descriptive with a predominantly qualitative approach. With regard to technical procedures, the steps are synthesized through a semiotic analysis of the color chart of a fashion collection in relation to its concept using the semiotics theories of Charles S. Peirce, William Morris, and Roland Barthes. The fashion collection used in the research was selected from a Brazilian fashion contest called Concurso dos Novos presented at the Dragão Fashion Brasil event. The hypothesis addressed here revolves around how color appears within the development of the creative process of fashion products as one of the main elements to build the assertive visual message that will guide the narrative concept of fashion collections, connecting with the sensory perception of the observers and making them understand the prospect message projected by the designers.

### KEYWORDS

*fashion | color symbolism | color perception | semiotics | chromatic message*

## Textile crafts: The middle path

Deepshikha<sup>a</sup>

<sup>a</sup>Independent Researcher

<sup>\*</sup>Corresponding author: dee.shikhajha@gmail.com

Textile traditions of India are wide and varied cultural transmitters of the rich heritage since ancient times. In the last two decades, Government, NGOs and Private institutions have played a significant role in upscaling and popularizing crafts globally while retaining the original essence of the craft and/or merging them with foreign styles for contemporary looks. The present poster presents a brief case study of four textile crafts – Woven (Maheshwari), Printed (Block prints), Painted (Kalamkari) and Embroidered (Zardozi) from Central (Madhya Pradesh), West (Rajasthan), Southern (Tamil Nadu) and Northern (Uttar Pradesh) parts of India, respectively.

Wearable technology is one of the key trends in design, research, fashion and retail. Researchers globally have attempted to merge wearable electronics with textiles for specific purposes, ranging from health, sports, fashion, education, etc. Digital crafts have been termed as crafts (textile or others) embedded with technology for specific purposes. This poster presents key examples of wearable textiles from across the globe. These examples form a plausible source of inspiration for designing digital crafts with respect to India and applications specific to India and elsewhere.

Why the middle path? The first viewpoint is that of authors, craft enthusiasts, government and non-government bodies, educators among others who have worked relentlessly to revive and preserve traditional (textile) crafts of India in its original style. Detailed ethnographic studies have been conducted to write books, shoot documentaries, films, conduct fashion shows, launching unique brands, rehabilitating craftsmen and craft villages, etc. It is not an overstatement to mention that revival and preservation of crafts is one of the most important objectives of their life purpose. The second viewpoint is that of wearable technologists. They believe in merging technology seamlessly in our lifestyle and textile offers a flexible and reliable medium, especially because of its proximity to our body. But embedding technology in textiles or crafts diminishes the craft or textile design element in many cases and highlights the embedded technology, function and application more. The textile or craft takes a back-seat, hence, this generates a gap between textile craft enthusiasts and technologists. Some researchers have affirmed that crafts are emotionally charged hierarchical artifacts and digital crafts can never replace the emotions, feelings and virtues associated with original crafts. Hence, rendering digital crafts a mere knock-off.

Thus, in this poster the author presents four original textile crafts and possibilities for technological intervention which is seamless while retaining essence of craftsmanship in a contemporary digital craft. The propositions hence follow a middle path balancing the ethos of craft enthusiasts while integrating minimal technology from the wearable researchers' group. The challenges in terms of digital evolution have also been mentioned. The poster encourages other researchers to work on similar lines, conduct in-depth qualitative and quantitative studies and also chalk possibilities for creating novel brand identities, a niche in the textile/craft/wearable segments while retaining indigeneity.

### KEYWORDS

textile heritage | digital textiles | trends



## What connects graphic design of Japan and Denmark?

Irena Iljaž, Klementina Možina\*

University of Ljubljana, Slovenia

\*Corresponding author: klementina.mozina@ntf.uni-lj.si

Culture is a part of every one of us. The main part of any culture is habits, norms and beliefs, along with art (including architecture, interior, graphic and media design). Art has been influenced by culture as much as was culture by art. Worldwide exploration allowed us to gain new knowledge; however, it also changed our perception and provided a new insight into our own cultural identities. Therefore, it is not surprising to find similar art styles in faraway locations. Art was shaped not only with a specific culture in mind, but with the help of foreign influences. All of the above mentioned is nowadays a part of the cultural heritage that is typical of each society.

We have noticed similarities in aesthetics and their primary cultural habits of remote countries, Japan and Denmark. Although such a claim can be surprising or even disbelieving, a further study of geography, history, social and cultural characteristics of the two countries has formed many parallels. Moreover, we have seen similarities in the awareness of white space, colour use and colour combinations, and ideas behind the design. All of the latter have shaped present-day countries and their cultural identities.

The aesthetic and design principles (colour, typography, motifs, shapes) of both nations were described and common aesthetic values that link Japanese and Danish design were established. Colours (or even absence of colours) are one of the most important elements of both designs. Commonly used colours are rooted in the history and landscape, which means that people primarily used colours that were available in the environment and were inspired by that same environment. The Japanese colour system is especially complex and explicit with colour names. Even though we have a wide range of colours that are used today, cultures still have tendencies to particular hues. People are keen to connect some colours with the characteristics from the habitat; hence, the culture has shaped how specific colours are perceived.

The aim of this study was to connect distant cultures, and to present differences and similarities found in both Japanese and Danish art and design – displayed visually in a form of corporate identities for a botanical garden. Corporate identities (consisting of a logotype and various applications) are much more accessible to the masses and thus can become part of a nation's culture through time. The analysis of these topics provided not only the reasons for choosing specific colours, typefaces, and usage of white space, but also a meaning behind all of these elements. Even though design solutions were based on similar shapes, previously mentioned principles altered the way Japanese and Danish corporate identities communicate and look. The results show subtle or great differences between the Japanese and Danish design without using either language, thus displaying the visual language of each nation.

### KEYWORDS

aesthetic | colour | Denmark | graphic design | Japan

## Analysis of color feature extraction processing in color constancy network by CNN

Shunta Sugiyama<sup>a\*</sup>, Yoshitsugu Manabe<sup>a</sup>, Noriko Yata<sup>a</sup>

<sup>a</sup>Chiba University, Japan

\*Corresponding author: falcon.cryptomeria@gmail.com

Color constancy is a human visual property that the color of an object can be recognized correctly, even when the color of the illumination light changes. It is considered that there is a specific mechanism that corrects for color during the light enters the eye to the brain recognizes the color. However, the detailed mechanism of color constancy has not been explained yet, and multiple mechanisms such as memory and adaptation of the color of an object may be working simultaneously.

In this study, we construct a network that reproduces human color constancy with pix2pix based on a convolutional neural network (CNN) and analyzes the mechanism by the network. The training was performed with 4500 pairs of training images, a batch size of 1, an epoch number of 200, and a step size of 0.00023. The training images are CG images in which the colors of the light sources are randomly set are generated by physically based rendering. We use paired CG images of the same objects lighted by a colored and white light source as input and training images. We use Physically Based Rendering (PBRT) considering physical phenomena such as spectral distribution and spectral reflectance to generate CG images of training data. We visualize the feature map of the network trained using the created CG image, investigate what processing each layer does. This network can be evaluated by the Root Mean Square Error (RMSE) of the image under the colored light source at the input and the corrected image. Feature maps when the RMSE value is below a certain threshold are used for analysis.

By inputting the image under the colored light source to the trained network, the image corrected under the white light source and feature maps of the visualized network are obtained. Then, the highlight part and the background part are extracted from the feature maps. The relationship between the most frequent value of hue in HSV in all pixels of these extracted feature maps and the color temperature of the image under the colored light sources input to the network is examined. From these results, we consider how the color information of the highlights and background is related to the color constancy.

In many feature maps, the hue's mode value continued to be constant regardless of the color temperature in both the highlight part and the background part. In the feature map of the first layer, the amount of change in the hue value decreased as the color temperature increased and it was found that the hue of the highlight/background portion changed when the color temperature was close to the temperature of the white light. Therefore, it can be said that the difference in the color of the illumination light affects the color information extraction process of the network.

### KEYWORDS

color constancy | convolutional neural network | machine learning

## A method for estimating the spectral sensitivity of a camera using optimization techniques

Shogo Nishi<sup>a\*</sup>

<sup>a</sup>Osaka Electro-Communication University, Neyagawa, JAPAN

\*Corresponding author: s-nishi@osakac.ac.jp

Digital cameras are products that imitate human color perception, and there is a close relationship between the spectral sensitivity of the sensor and the camera output. Therefore, if, for example, the spectral information of a target is to be obtained from the camera output, the spectral response information of the sensor is essential. In general, however, manufacturers do not publish spectral sensitivity information. To obtain this information, users need to prepare expensive equipment such as monochromators and spectroradiometers, so an inexpensive and simple method to obtain the spectral response of a camera is desired.

An ordinary digital camera has three RGB spectral response characteristics, and it can be considered that the camera output can be obtained according to the combination of these characteristics. Alternatively, the three spectral response properties can be considered to be composed of a finite combination of wavelength band-limited. Therefore, in this paper, we propose a method for estimating the spectral response of the camera using an optimization method. A genetic algorithm was employed as an optimization method. Genetic algorithms are algorithms that engineer the evolution of an organism and perform probabilistic searches and optimizations.

In the experiment, the spectral sensitivity of the Canon D60 was used as an estimation target. To improve the estimation accuracy by irradiating an object uniformly, a measurement device that can irradiate illumination light from multiple directions was used. The camera output for the camera sensitivity estimation is an image taken with an X-rite ColorChecker Digital SG. As a genetic operation, we first generated an initial population using spectral sensitivity, which is publicly available as a database. Since the spectral sensitivity of color cameras is in three bands: short, medium, and long wavelengths, there is no need to try an infinite number of combinations. Therefore, the use of a database is effective for efficient solution search. In the selection process, an elite preservation strategy was adopted. At that time, it is necessary to evaluate the degree of fitness, which was evaluated by CIE  $\Delta E_{ab}$  in this study. In the crossover, we swapped arbitrary wavelength bands, and for mutations, we changed the peak spectral sensitivity. The number of generations was fixed at 1000 and the spectral sensitivity was estimated and good results were obtained after several trials. In the paper, we will report the improvement of the fitness function and its application to camera sensitivity estimation for smartphones.

### KEYWORDS

spectral sensitivity estimation | genetic algorithm | spectral sensitivity database

## Variation and Classification of White in Architecture based on Field Survey

Kaoruko Kitamura<sup>a\*</sup>, Haruno Tsuda<sup>b</sup>, Azusa Takei<sup>b</sup>,  
Nozomu Yoshizawa<sup>b</sup>

<sup>a</sup>Mukogawa Women's University, Hyogo, Japan

<sup>b</sup>Tokyo University of Science, Chiba, Japan

\*Corresponding author: kitamura@mukogawa-u.ac.jp

Colour and finish in architecture have changed with the architectural style. It is well known that the use of white, especially, has changed remarkably across the age of Modern Architecture. White sets off other colours as a background, expresses its characteristic meaning, and amplifies the effects of light. To consider the historical variations in colour, this research focuses on «white» in architecture. The purpose of this research is to grasp the appearance of white through field surveys of architects' works and clarify the variations in white that affect perceived colour and expression of light.

We listed articles which referred to white in Japanese representative architectural magazines and books published between 1965 and 2019. Of these, 55 cases completed from 1932 to 2019 were selected for field surveys. The target surfaces were whitish finish in architecture. We measured colour in three different ways for one target surface: colour under standard illuminant, colour under actual lighting, and perceived colour. The first was measured by a spectral colorimeter with D65 light source. It is what is called object colour generally. The second was measured by non-contact type luminance and colour measurement devices. The last was judged by a skilled observer using a colour chart software for tablet devices. The tablet device was covered by a black matte box with a small opening to look inside, and the observer selected the same colour on the tablet screen as the perceived colour on the target surface. With these three kinds of measurements in actual architecture, L'u'v' values of the selected colours were measured by a spectral radiance meter in a darkroom and plotted in CIE 1976 UCS colour space to compare mutually. Field surveys were carried out from October 2017 to September 2019, from 7 a.m. to after sunset. The following results were obtained. Colour under standard illuminant was slightly yellowish as the completion year was old. To verify the influence of aging, additionally, we measured white samples of 1954-2015 in Japanese standard colour samples in safekeeping. From the comparison, it became clear that both white on the target surface in actual architecture and white on the standard colour samples similarly changed into yellowish with age.

Colours under actual lighting were distributed along yellowish-blueish direction in u'v' colour space. It is thought that white on the target surface was distributed to yellowish white under actual lighting such as indoor artificial lighting with low colour temperature, and to bluish white under the daylight with high colour temperature. In addition, white under actual lighting was sometimes distributed in greenish white by reflecting the colour of grass and leaves outside the window.

Perceived colour was ranged from colour under standard illuminant to colour under actual lighting. We can say that perceived "white" showing similarity to colour under standard illuminant is emphasized its whiteness by observer's adaptation. However, whether perceived colour is similar to colour under standard illuminant or not depends on the use of light in the actual space. Based on the change that the meaning of "white" expressed by architects had changed across the age of Modern Architecture, colours measured in our surveys were compared with the completion years and the generation of architects. According to this, perceived colour differed in chronology. In many architectural works before the early 1990s, perceived colour was often similar to colour under standard illuminant. In contrast, perceived colour in several works after 2010s was similar to colour under actual lighting. This means that observers perceive the white or whitish colour highly affected by the actual lighting without adaptation. It is thought that perceived white was not whiteness emphasized as colour, but white to project light onto itself.

### KEYWORDS

white | architecture | age | lighting | perceived colour

## The impact of noise estimation on dehazing

Jessica El Khoury

ImViA Laboratory, Université Bourgogne Franche-Comté, Dijon, France  
Corresponding author: jessica.el-khoury@u-bourgogne.fr

The reduction of outdoor visibility is usually caused by the presence of particles in the atmosphere. The nature and the concentration of these particles define the resulting phenomenon: it could be haze, fog, smoke or pollution. Images captured in these atmospheric conditions suffer from poor contrast and bad visibility. This obstructs the performance of many vision understanding applications, such as monitored driving, video surveillance and satellite imaging.

To remove haze and improve the quality of degraded images, many dehazing methods have been developed in the last decade. Recent methods require only a hazy image provided by simple and affordable imaging systems. Among these numerous methods, only a few ones handle noise, which is always present in hazy images and is amplified through dehazing when it is ignored.

Noise in images is mainly due either to environment (extrinsic noise) or sensor (intrinsic noise). As the transmission of light coming from scenes' objects is exponentially attenuated and comes quickly down to zero in presence of haze, the noise is greatly amplified at high haze densities and long distances.

When the noise is ignored or inaccurately estimated, this prevents dehazing methods from providing images of high quality standards.

In order to investigate the importance of the accurate estimation and the removal of noise in hazy images, we used the CHIC (Color Hazy Image for Comparison) database, which provides, for a given scene, the fog-free image and a set of images with different fog densities. For each scene, a number of parameters are available like the distance from the camera of known objects such as Macbeth Color Checkers, their radiance, and the fog level through transmittance. Using these data, we measured the noise in foggy images across fog densities and we calculated dehazed images while incorporating the accurate noise value in the corresponding model. We estimated also dehazed images using noise values diverged from the accurate one. The biased values were calculated by adding and subtracting small ratio from the accurate value to simulate over estimation and under estimation of noise, respectively.

To evaluate the quality of dehazed images and investigate the impact of noise estimation accuracy on the recovered features, we used some quality and color difference metrics. It was not surprising that when the estimated value of noise is closer to the real value, the colors are closer to the original ones and the overall quality of dehazed images is higher.

To the best of our knowledge, the quantification of color and quality degradation caused by the lack of the accuracy in noise estimation, has never been addressed before. Through this study, we point out the importance to stimulate researchers' awareness of the need to include denoising as a mandatory treatment into dehazing and to focus on the proper modelling of noise that will guarantee an accurate estimation.

### KEYWORDS

dehazing | denoising | image quality | color

## Architectural Finishes: New European standard within build heritage

Kathrin Hinrichs Degerblad<sup>a\*</sup>, Edwin Verweij<sup>b</sup>

<sup>a</sup>Riksantikvarieämbetet, Sweden

<sup>b</sup>NIKU, Norway

\*Corresponding author: kathrin.hinrichs.degerblad@raa.se

Within the conservation of cultural heritage, a new European standard is long-awaited for the investigation of architectural finishes. Experts with various background compiled a document, based on consensus, that is currently under review and is expected to be published in 2021.

Standards are 'codes of good practice' where the focus is on the normative aspects. By describing the phases of an investigation project; initiating, commissioning and executing, all the stakeholders involved will benefit from the deliverables that will be more uniform, comparable and easier accessible.

When collecting, processing and documenting the data, several methods can be used to disseminate the findings. However, these methods cannot be taken up in a standard as its mainly normative. Working methods can only be mentioned in the references or in the annexes to exemplify how to disseminate findings in a good and pedagogic way.

This poster will focus on various visual methods to visualize the findings in clear and unambiguous ways; for example, on how to create period charts by combining architectural elements with an historical timeline, show how micrographs could be used or how colour coding can be integrated into the documentation. All these aspects will contribute to implement the standard and to create a broader platform to exchange information.

It will help to communicate the knowledge gained of the object under investigation, to recognize alterations, to assess the condition aspects and to plan for future maintenance programs in a universal and comparable way when using the standard the investigation of architectural finishes.

### KEYWORDS

architectural finishes | european standard | APR

## City colour at night: lighting to preserve heritage and wayfinding

Mariana Noguera<sup>a\*</sup>, João Pernão<sup>a</sup>

<sup>a</sup>CIAUD - Lisbon School of Architecture - Universidade de Lisboa  
<sup>\*</sup>Corresponding author: arqmariananog@gmail.com

Colours affect the way we perceive space. The cities we inhabit are a construction of this space, in which we form images from references mainly concentrated on the visual quality we find. In this complex landscape, full of elements, the legibility of an object facilitates the recognition of the location. The orientation in the city landscape can come from the sensation of colour, the incidence of light or the shapes of the objects, and those references, marked in our perception, give us the certainty of which way to go.

During the night, if these elements remain legible and identifiable, it can not only offer security, but also deepen the experience and exchange of the individual with the city. Night lighting reveals the environment and shapes the way we use and understand urban space. This lighting should consider the highlighting of important built elements of the city (its references), contributing to the recognition of the space.

In the city centres, historic buildings are the most important references to this understanding and recognition of urban space. A light design project should be concerned with this important role and address the principles of preservation of these buildings.

Within this principle of preservation, it is instituted in several documents, that no changes should be made to the appearance of the coating materials of their surfaces, preserving their chromatic authenticity in the urban setting during the day and at night.

Night lighting will always be different from daytime however, the elements of aesthetic and material recognition that make heritage buildings understood as having a unique identity, should be preserved, and not altered in their night reading. We have seen the use of night lighting with different colour temperatures, mainly used by economic principles, instead of being based on a study about the impact of this lighting on the perception of urban complexes and on the hierarchy of urban space. The result is often an undesirable effect in the hierarchical presentation of important buildings in urban landscape, in the human visual comfort and in the orientation of the visitors.

It has also been used coloured illuminations in heritage buildings, modifying its image in the night-time in a way it cannot be recognized. This type of illumination should be used only as an ephemeral spectacle of transformation and enchantment aimed at celebrating a specific event, for a short period of time. But when that becomes a rule, or a definitive project, the disruption tends to be greater than the gain. It is necessary to establish rules and good practices that address the lighting of urban complexes and heritage buildings from a holistic point of view, contemplating the economy and sustainability of lighting systems and appliances, but also including studies on the perception and the memory of the city image, with its hierarchies and references, preserving the identity and characteristic of its most important elements, including its colours. Lighting of historical centres should be placed in the realm of heritage and urban landscape.

### KEYWORDS

*light color perception | heritage | light intervention | legibility | wayfinding*

## The authenticity in the visual and chromatic identity of the historical center of Tiradentes

Bárbara Silva<sup>a\*</sup>, João Pernão<sup>a</sup>

<sup>a</sup>CIAUD, Lisbon School of Architecture; Universidade de Lisboa, Lisbon, Portugal  
<sup>\*</sup>Corresponding author: [barbaramsilva@campus.ul.pt](mailto:barbaramsilva@campus.ul.pt)

Tiradentes is part of an important group of historical cities in Brazil, which emerged in the early eighteenth century, due to the discovery of gold in the region named "Minas Gerais". The classification of these cities in national level was related to the introduction of heritage conservation policies in Brazil, at the beginning of the 20<sup>th</sup> century, when they were considered a symbol of traditional culture, because they had remained isolated, without major interventions for a period of time close to a century.

Despite the importance of the aesthetic aspect to their heritage value, it is possible to affirm that the visual identity of these cities faces constant risks of de-characterisation: in the one hand, it is known that the conservation of built heritage in Brazil has faced technical, economic and political problems, and in the other hand, the lack of systematised information on the construction techniques in colonial Brazil and the scarcity of information about colours and coating materials in Minas Gerais are also relevant threats to their identity. In most of these cities, there are also risks related to the impacts arising from the intense touristic activities.

This paper aims to present a study, which is part of an ongoing PhD research, with the purpose to characterise the chromatic identity of the historical centre of Tiradentes, which is one of the most relevant cities within the mentioned group of classified cities. It is intended to discuss the authenticity in its current visual and chromatic identity, by enlarging the knowledge about materials, coating techniques and colours used nowadays and in the past periods in the history of the city.

To develop this investigation, different methods were used to collect data, including literature review and field research carried out between August and September of 2019, where were performed exploratory interviews, photographic records, direct observation, chromatic readings, collection of materials and samples, among others. With the results of the proposed study, it is expected to provide data to initiate an important discussion about the authenticity in Tiradentes' visual identity and to help establishing invariables in traditional materials, colours and coatings that could help ruling the conservation of its historical centre. Finally, it is considered that the results will positively impact the context of the global patrimonial culture, since knowledge, its transmission and dissemination, are instruments of preservation.

### KEYWORDS

*visual identity | chromatic identity | tiradentes | architecture | heritage conservation*



## The importance of color in the facades of collective housing of the Modern Movement: the Portuguese case

Mariana Costa<sup>a\*</sup>, João Pernão<sup>a</sup>,

<sup>a</sup>CIAUD, Lisbon School of Architecture, Universidade de Lisboa, Lisboa, Portugal  
\*Corresponding author: marianafsampaio@campus.ul.pt

Until the mid-twentieth century, photographs in architecture publications, such as magazines, newspapers and books, were, in the majority, in black and white. Depending on technical and graphic restrictions, the photographs of architecture built in the beginning of the century present an abstract materiality. These images concealed nuances, tones, variations of construction materials and colours applied to buildings.

Architectural solutions were mostly described by their technical and rational elements: plans, sections, elevations. The black and white photographs presented us an architecture that was mainly qualified for its volumetric characteristics, for the contrast between mass and void. It was an architecture that did not convey the emotions of the materiality with which it was built. Descriptive texts were then necessary for a better understanding of materiality.

One of the innovations introduced by the Modern Movement was precisely the use of new construction materials and, above all, the structural freedom made possible using reinforced concrete. The application of materials in their natural expression was also an innovation of the Modern Movement. It will not be inappropriate to affirm, therefore, that the material played an important part in consolidating the idea intended by the architect, as did the volume and the organization of the space. However, the material is the one that presents itself less reliable, the one that finds fewer references and studies.

This article aims to identify the colours and materiality of buildings of the Modern Movement in Lisbon, Portugal, built in the 1950s. The Infante Santo's housing complex rehearses the principles of urbanism and architecture defined in the Athens Charter, here adapted to Lisbon's reality. The building's peculiar characteristic is its use of colours, materiality and the incorporation of art on the facade, with a variety of tones and nuances that were not possible to be described on the black and white photography of the time.

Through a comparative methodology that considers photographs from the time and current ones, both in black and white, this study intends to identify changes in the facades of these buildings over the years. To this methodology, data collection of materials and colours existing today will be added, intended to assess changes in materiality and colours, both in applied materials and raw materials.

This study aims to identify a colour palette that could reveal a new contribution to architectural facades' analysis. It presents useful conclusions by adding information about the richness of colour and materiality to the abstract black and white architectural representation.

### KEYWORDS

*Modern Movement | architecture | collective housing | facade materiality | colour*

## A sensory colouration of the territory: between reality and fiction for the creation of an identity

Sophie Lapègue

LARA-SEPPIA, Allph@, University Toulouse II Jean-Jaurès, France  
Corresponding author: sophie.lapegue@live.fr

The territory vacillates between the identity of the place, the social link and political and economic appropriation. The Argonne (Marne (51), France) is one of these territories with a strong past. The war has redrawn its landscape, leaving behind it a bruised space, living in memory, on the fringes of reality and its development. This heavy past is today a social and economic struggle. How can the territory reinvent itself? Can colour create identity? What tools does the designer use to create?

The landscape is an inexhaustible source of sensory and emotional information. It is a fundamental element of local identity and the quality of life of the population. However, this familiar space evolves, and these changes sometimes have harmful effects on identity representations and perceptions. In order to revitalize the Argonne on an economic, cultural, social and tourist level, the designer relies on a senso-chromatic analysis of the landscapes forming this territory. The aim is to question what connects us to a landscape on a sensory and chromatic level, and to bring out new systems of interpretation: a new way of entering into resonance with one's environment.

Based on a digital photographic practice, combined with chromatic readings identifying sensations and emotions of the terrain, the designer seeks to retranscribe the particularity of the place through combinatorial cartographies. By combining data relating to the landscape (natural formation, culture, history...) and singular identity records, the designer, like the painter, composes and decomposes palettes, between colours and sensations, giving rise to colour charts of unique landscape atmospheres. All the tension of his work lies here: preserving an observed reality and its natural colours, while exploiting digital tools as the gateway to a fiction. This experience lends itself to the game of space-time. Indeed, the representation of its states of colouring is in the image of the world around us and the tools we have to communicate them: taking the time to cultivate the colours of the territory through field and workshop work in the face of an economic reality, often dictated by digital technology, in rapid demand for results and output.

Through this practice, it is a question of representing an observed reality in order to, little by little, give to dream and thus create an immersive imagination, impregnating the whole ecosystem of the territory with this new poetic universe, in its temporality and its modalities. This process of linking also questions the original identity of the place, its life, its evolution and its states of appropriation. The past is transformed into a source of memories giving way to a colourful allegory. The representation and retranscription of the colours from the Argonne are organised around a communication tool, adapting the discourse, involving the population in search of this new identity. This vision, more positive, opens new perspectives. Observation, although based on a real study, is gradually becoming appropriate, drawing the contours of the designer's creative universe. Imagination blends in, fiction sets in, sensory colouring is revealed.

### KEYWORDS

colouration | sensory | identity | territory | fiction

## Cross-cultural comparison of color emotions and preference of cotton fabrics dyed with persimmon and indigo

Jongmyoung Choi<sup>a</sup>, Sang Hee Lee<sup>b</sup>, Eunjou Yi<sup>b\*</sup>

<sup>a</sup>Chungbuk National University, Korea

<sup>b</sup>Jeju National University, Korea

\*Corresponding author: ejyi@jejunu.ac.kr

Persimmon and indigo have been main traditional natural dyeing stuffs in Korea and they have witnessed an increased potential as cultural fashion products among international consumers owing to their cultural values as well as their environment-friendly attributes. This cross-cultural study was purposed to describe color emotional aspects of fabric dyed with the natural dyes in order to enhance the range of products employed in fashion and textile design and to improve global market. Precisely, we attempted to compare Koreans and Chinese focusing on deriving significant physical colorimetric attributes that can be used to quantify their color emotion and preference of the dyed fabrics. Cotton fabrics were dyed with persimmon and indigo respectively in a range of shades, and three different tones for each dye were obtained; pale, soft, and dull for persimmon and light grayish, soft, and dark for indigo respectively. Korean college students and Chinese counterpart in Korea were recruited and invited to give scores of color emotion terms and color preference of six single colors of dyed fabric samples. For quantifying the analysis, t-test, one-way ANOVA, and linear regression were employed.

As results, both national groups felt similarly in terms of primary color sensation such as 'Warm', 'Light', 'Soft, and 'Strong' while for more complicated emotion terms including 'Natural', 'Dynamic', 'and 'Elegant', they showed significant different responses. Colors of persimmon-dyed cotton was perceived as more conservative, more natural, and less dynamic by Koreans than by Chinese, which might be resulted from that Korean students have known the naturally dyed fabric better than Chinese people have. For Indigo-dyed fabrics, light grayish-toned fabric, the most weakly dyed one was found to have national differences in 'Natural', 'Pleasant', 'Dynamic', and 'Gentle', which precisely indicated that Korean group seemed to feel it as more natural, less dynamic, and less gentle while Chinese did it as more pleasant and more gentle. Color emotions for both naturally dyed fabrics were revealed as significantly correlated with colorimetric attributes in Munsell and CIE color system. The term 'Warm' was found as more strongly associated with colorimetric attributes than any other terms in that both Koreans and Chinese responded higher rates as color shades were lighter and more colorful. As for cross-cultural comparison, color emotion such as 'Natural', 'Comfort', and 'Conservative' tended to be evoked by colorimetric attributes more significantly by Korean people than by Chinese. In terms of color preference of persimmon-dyed fabric, both national groups gave the highest rates to pale-toned fabric, which showed agreement with a previous study (Yi&Shamey, 2015) reporting more weakly dyed fabric with persimmon was preferred by both Koreans and Americans. Color preference of two differently dyed fabrics with natural stuff showed significant negative relationship with colorfulness indicators including Munsell C and CIE C\*. Finally color preference by each national group was quantified with colorimetric attributes and color emotion terms using regression models which could be utilized to design more sensible naturally dyed fabric for international consumers.

### KEYWORDS

cross-cultural comparison | color emotion and preference | persimmon dye | indigo dye | cotton fabric

## Recovering reflectance of a partially shaded image under colored scene illuminant

Harumi Kawamura

Salesian Polytechnic, Machida, Tokyo  
Corresponding author: h-kawamura@salesio-sp.ac.jp

A method for recovering reflectance from a partially shaded image under colored scene illuminant is proposed. The shaded regions in the image often hinder from recovering the reflectance because colors of the regions with and without shades are different each other even if they have same reflectance. The proposed method enables to recover the reflectance under the above conditions using Retinex theory and gray world assumption.

According to the Retinex theory, reflectance of each region in an image can be recovered under the hypothesis that the difference of nearby colors under the scene illuminants is smaller than those by the object edge. However, when the regions include shades, the difference of the colors with and without shades can be large enough to be judged as edge of the object regions. Furthermore, the reflectance recovered by the theory is relative one because colors of the scene illuminants can't be estimated in case where the strength of the scene illuminant doesn't change so much throughout the scene.

In order to recover the reflectance in the partially shaded image under the colored scene illuminants, proposed method has two features. The first uses the property that difference of hue in the region with and without shades doesn't change so much compared to the difference of "value" which means lightness in HSV space. By using this property, the region including shades is regarded as the same object region to those without shades although there is a large gap between colors with and without shades. The second one estimates colors of scene illuminants by using the method for two and more illuminants in the scene. Among the conventional methods, gray-world-assumption based one is used. The method can estimate colors of the scene illuminants by averaging all colors in the image by assuming that the average color of the all objects in the scene is gray. Because this gray-world-assumption based method uses global features and shades themselves are also occurred not locally but globally. When applied this illuminant estimation method, the image is firstly divided into small regions and average colors of each small region, which are judged to satisfy the gray-world-assumption, are calculated as local illuminant colors. By unifying the local illuminant colors, final estimation will be derived.

In the experiments, computer generated images, which are made of colored Mondrian pattern and colored illuminants, are used and shades are added to the right half of the image. The experimental results show that shaded region is estimated as same as the non-shaded one. Furthermore, colors of the scene illuminants in the image can be estimated.

### KEYWORDS

color constancy | Retinex theory | illuminant color estimation | shaded image

## Artificial rainbow and beyond

Joaquim Santos

Lusiada University, Faculty of Architecture and Arts, Lisbon, Portugal  
Lusiada Institute of Investigation and Development.  
CITAD, Research Center for Territory, Architecture and Design.  
Corresponding author: marcelino.c.santos@gmail.com

Is there a rainbow in Wassily Kandinsky's *Cossacks*?

Natural beauty may have been out there from the time of the Big Bang, but it is a phenomenon not recognized prior to human judgement. Subsequently introduced by an artificial factor, a man-made-thing, a concept into the natural world of phenomena. Natural beauty is not a natural thing brought about by nature alone. Before anything else, it is a creation of human judgement, it is a quality given to things we have selected by pleasure and affection, it is the creation of the symbolic, a realm that makes civilization meaningful. Natural versus artificial colours connects us up to the origins of species and to the origins of civilization. It is a particular moment of reflection that grounds past, present and future within the context of both art and science. Natural colours of galaxies that telescopes such as Hubble gives us are not necessarily natural to the extent that much of what we observe is radiation to which our eyes are blind. Thus, under some circumstances, artificial colour embodies an intricate connection to what is natural.

However, artwork as a man-created-thing seems to exist at the core of artificial colours versus natural colours in a way that engages us differently, where we judge what we are and what we create besides the natural world we live in. But this is not a particularly new issue. The *via moderna* put this problem clearly under the pen, or brush, of aestheticians and artists. Arguments beyond mimesis spread widely from sixteenth century Italy. Awareness of what we see around us seemed to become awareness of what we are actually creating, and this turning point led to important discussions that show their influence even today. By creating a possibility of dealing with an infinity of colours and in order to make that possibility meaningful we need to concentrate ourselves on the created thing even before we can speculate on how art can benefit from such miraculous improvement. A higher vital force of creation strongly resonates with freedom. The term «virtual» is appealing to the same extent that though itself is the software of our mind and thus virtual, too. The rise and development of abstract art by emphasizing mental processes may have given a major contribution to our digital culture where infinity has shapes and forms and, last but not least, among them colour certainly is a tremendous one. Perhaps that is the reason why fractal beauty had such a strong impact on our digital colour visions and perception. However, it seems avoidable the sense of the material object and simple things such as the demand for the most perfect screen show a need for materialization. We imagine colours, we think by colours, but we are also flesh and we need ways of expressing ourselves that can engage us into a totality equivalent to what we are body-mind-world. We imagine colour but we need to see colours outside us. Our eyes speak and are remarkable feeling makers.

As Ludwig Mies van der Rohe called attention to free plan, we have a much higher degree of freedom but, then, it also requires a much higher degree of awareness and rationality to avoid chaos. We may be able to create infinity in colour but, perhaps, an artificial digital rainbow will be ever able to reference our ethical posture, to return to ethics and to a comprehensive sense of what is the world we live in and transform and what are how magic creations in art and science. However, this must not mean a return to the renaissance sense of mimesis. This artificial rainbow already comprises all the twentieth and twenty first centuries development of art and its colours symbolize awareness of mental processes that take us to art and science. Beyond imagination and freedom, what is striking on digital colours might be what they embody as statement at an acme of civilization and humankindness. An artificial rainbow certainly mirrors me, you, us!

### KEYWORDS

*mimesis* | rainbow | natural | artificial | colour

This work is financed by national funds of FCT (Foundation for Science and Technology) under the Project UIDB/04026/2020. Lusiada University and CITAD.

## Color and discursive meaning in historical facades of the Tampico city, Mexico

Jimena Vanina Odetti<sup>a\*</sup>, Rebeca Isadora Lozano Castro<sup>b</sup>

<sup>a</sup>Instituto Tecnológico Mario Molina Pasquel y Henríquez, Campus Puerto Vallarta, México.

<sup>b</sup>Universidad Autónoma de Tamaulipas, Facultad de Arquitectura, Diseño y Urbanismo, México.

\*Corresponding author: jimeode@hotmail.com

This work deals with the study of color and the discursive means of the identifying graphics on facades of historical buildings in Tampico city, Mexico. The study has detected the presence of 104 facades of historical buildings that contain identifying graphics with the presence of certain colors that characterize the symbolic image of these buildings. These buildings, such as large multi-family buildings (three to five floors) with shops on the first floor, or smaller ones as a house (one or two floors) are scattered in the first sector of the historic downtown and contribute to the chromatic conformation of Tampico's urban landscape. The ancient architectural design considered space, location in its planning, but also the color that fully coincided with the time, the architectural trend (style) and the construction materials in its choice, as well as the social imaginaries corresponding to the foreign cultures. (American, English, Belgian, Dutch, German, among others) preferably (Ortiz and Ortiz, 2015). In this sense, the architecture, the identifying graphic and its colors were not included in the local structure, but rather the culture and foreign identity was respected and became part of the local context. The value of memory accumulated through color was discursively re-signified in the exposed facade as part of the architecture; and this changed its media coverage on public roads. In other words, it maintained a symbolic representation with the notion of hierarchical discursive significance by social power of the ruling class. The dominant colors correspond to: light brown or beige with discreet intensity; red on earthy yellow, but also gold; the blue color attenuated and related to the clothing of the time; the gray color corresponding to the epochal texture; the natural color of construction materials (gray for concrete or reddish for brick); the attenuating pink (or rosewood) color; white with bourgeois or political symbolism (occasionally); among others. The observed tones warn not to be of the brilliance and saturation that the current ones in the construction. Color appears in this project, as a device to study from the social construction of a visual discourse, but also from the configuration of a set of elements that helped to found the identity of a social sector at the time these buildings were built, and particularly these identifying graphics. In this sense, it is proposed that the study of the selected graphics and their colors make up a cultural legacy for the city of Tampico, worthy of highlighting and rescuing, as part of its history and its configuration of cultural identity. From the methodology, a photographic survey of the facades and the identifying graphics is carried out, to generate with the selected sample, the chromatic palettes identified with the Natural Color System, to then link them with the visual discourse analysis, from the era and towards the present time of the urban environment in which they are found.

### KEYWORDS

*cultural identity and color | architecture and color | identifying graphic | visual discourse*

## Multispectral dehazing versus color dehazing

Pedro J. Molina-Fuentes, Miguel A. Martínez-Domingo,  
Eva M. Valero, Juan L. Nieves, Javier Romero,  
Javier Hernández-Andrés\*

Color Imaging Lab, University of Granada, SPAIN  
\*Corresponding author: javierha@ugr.es

Under fog or haze images are degraded due to scattering and attenuation of atmospheric particles, reducing the contrast and visibility, changing the color and making the object features difficult to identify. This degradation depends on the distance, the density of atmospheric particles and on the wavelength. The techniques to eliminate this degradation, named as dehazing (or defogging), are crucial in air and maritime transport, surveillance, driver assistance systems, remote sensing, etc. Recently technological advances have allowed the proliferation of multispectral and hyperspectral systems for image capture in a wide range of applications. We focus on single image dehazing methods because they do not require user interaction nor additional information (such as depth maps or some prior knowledge about the images). Five algorithms are tested (DCP (Dark Channel Prior), Meng, Tarel, DehazeNet and Berman) on the SHIA database (Spectral Hazy Image database for Assessment) which consists of hyperspectral images (from 450 to 720nm, every 10nm) of a scene under different levels of fog (levels 1 to 9), including a haze-free image. Eleven different metrics are evaluated (e descriptor, r descriptor, descriptor, Laplacian descriptor (LAP), Grey Mean Gradient (GMG), Standard Deviation (STD), Information Entropy (H), Mean Squared Error (MSE), Peak Signal to Noise Ratio (PSNR), Structural Similarity (SSIM), Natural Image Quality Evaluator (NIQE)). A survey, answered by 125 subjects, tested the subjective similarity between the haze-free and dehazed images, and also the visibility for the objects present in the scene after dehazing. Our aim is to analyze the quality of the five dehazing algorithms and their dependence to the wavelength, density of fog, according to the results given by the eleven metrics evaluated and the subjective evaluation done by 125 subjects. For the hazy images (images affected by haze) there is a noticeable decrease in quality for the wavelength range between 450 and 500 nm due to the acquisition device of the SHIA database and in general the image quality increases when the wavelength increases. For the dehazed images (obtained by applying dehazing algorithms) we find similar trends in the metrics behaviour than for the original hazy or haze-free image, regarding the wavelength dependence, although there are some variations depending on the haze condition and the algorithm applied. This may be explained if we consider that the dehazing techniques tend to produce more artifacts for the lower wavelengths because of the inherent difficulty of the dehazing problem, which is high in this range. Regarding the haze level DehazeNet is clearly not able to cope with the higher haze conditions. Other algorithms, like Berman or DCP, produce more regular results, but in general it can be noticed that the images have more artifacts or lower quality as the haze level increases. According to the image quality metrics, the algorithms that achieve more consistent results across wavelengths and for different haze levels are Berman and DCP. DCP produces some artifacts like vignetting in the images' outer areas and the quality of the results decreases more sharply for the highest haze conditions. Dehazenet produces visually more pleasing results especially for the lowest haze condition, while Meng is rather consistent across wavelengths and haze levels, but less able to effectively decrease the loss of contrast in the images. In general, the answer to the question of which is the best algorithm depends on the goal that one has set for defining if the dehazing procedure has worked effectively; if this goal is to produce images that are more similar to the haze-free scene, then DehazeNet and Meng would be the best options. If the goal is to obtain better contrast and more visibility of the objects present in the scene, then Berman and DCP would be better than the rest. The results of the subjective evaluation do not correlate directly with any of the metrics analyzed. The SSIM or PSNR results show that Berman and DCP as most different from the haze-free images even for the highest haze condition, while the observers' results point out that DCP and Berman are more similar to the haze-free image.

### KEYWORDS

dehazing | defogging | color imaging | multispectral imaging | hyperspectral imaging

## The Brazility through the anthropophagic and colours optic: case study

Simone Thereza Alexandrino Maffei Simacek<sup>a\*</sup>,  
Carlos Kazunori Yoshimura<sup>a</sup>

<sup>a</sup>University of Sorocaba, Brazil

\*Corresponding author: [simone.maffei@prof.uniso.br](mailto:simone.maffei@prof.uniso.br)

The Brazilian culture has been built over the years by many different other cultures. The heterogeneity has been composed by – what Brazilians named – “the Brazility”. As general, we can understand the Brazility as a result of anthropophagic process, where we absorb, digest, and regurgitate the various cultures in a very personal way. Anthropophagy is a characteristic of Brazilians and an important tool for the harmonious heterogeneity of the country.

However, sometimes occurs a big mistake in this cited fact: the anthropophagic process is substituted by the appropriation process. Its consequences is a cultural depreciation through labeling and stereotyping. Focusing in this problematic, the present article intents to discuss how the Brazility can valorize other cultures through the anthropophagy optic, using the emotional and editorial design as tool.

We show a case study where we work with the Chinese culture and a selected fragment of popular artwork. This was possible utilizing the emotional design and UX design as conceptual theory to analyze our problematic, which we read and interpret that fragment of the essence of Chinese culture. The methodology that we used was the Design Thinking and Editorial design methods.

First, we determined some descendants of Chinese as a casuistry, which would give us the basis to create the personas and to investigate Chinese folk art within the three levels of design. Through the survey of artistic material that reached the reflective level of design, we selected the artworks of this case study.

Next, there was a chromatic study of Chinese artworks and a survey of a Brazilian chromatic palette that reached the same emotional level of design. The first validation took place within the same universe investigated and, later, with students from the university where the study was developed.

The final object created was the first of a series of illustrated books, where each illustration was the result of the anthropophagy redesigning of a Chinese artwork. “Looks. Art in another way” was illustrated in order to open horizons for the anthropophagic reading of Brazilians about Chinese culture. With this, we intent to promote the reduction of undue labeling, stereotyping, among other things that permeate Chinese culture in our Brazilian daily life.

### KEYWORDS

*emotional design | colour | anthropophagy | chinese culture | brazility*



## Surface appearance assessment as a tool for characterizing silver tarnishing

Amalia Siatoua<sup>b\*</sup>, Marvin Nurit<sup>b</sup>, Laura Brambilla<sup>a</sup>,  
Alamin Mansouri<sup>b</sup>, Gaëtan Le Goïc<sup>b</sup>, Christian Degriigny<sup>a\*</sup>

<sup>a</sup>Haute Ecole Arc Conservation Restauration, HES-SO University of Applied Sciences and arts Western Switzerland, Neuchâtel, Switzerland

<sup>b</sup>Laboratoire ImViA EA 7535- Université de Bourgogne Franche-Comté, Dijon, France

\*Corresponding author: amalia.siatoua@he-arc.ch, christian.degriigny@he-arc.ch

In historical collections containing silver artefacts, exposed to uncontrolled museum environments, the most common form of corrosion is tarnishing. Even though tarnishing creates a passive film on the metal surface <sup>[1]</sup>, it also generates alterations to the surface appearance, which are characterized by loss of shininess and color changes <sup>[2,3]</sup>. Additionally, the improper handling of silver objects with bare hands can lead to the appearance of fingerprints on the surface as a result of localized corrosion <sup>[4]</sup>.

In the field of Cultural Heritage most research on tarnishing is focused on understanding its formation mechanism <sup>[5,6,7]</sup> and proposing cleaning treatments <sup>[2,8]</sup>. The aim of this study is to create a methodology based on imaging techniques and computer vision that can be used as a tool for characterizing silver tarnishing. Additionally, geometrical and statistical indicators of change were examined for the classification of the degrees of tarnishing. Pure silver coupons, some with fingerprints on the surface, were artificially tarnished with a newly developed protocol, based on the use of sulfur deriving from egg proteins. This method allows to reproduce the natural tarnishing of historical silver collections. Various degrees of tarnishing were achieved corresponding to different color changes. Surface alterations were assessed using gloss measurements, colorimetry and an in-house Reflectance Transformation Imaging (RTI). In order to validate the results of the differences in tarnish layers Scanning Electron Microscopy equipped with Energy Dispersive X-rays Spectroscopy (SEM-EDS) and Linear Scanning Voltammetry (LSV) was implemented.

This research is performed in the framework of the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie Innovative Training Networks grant agreement No 813789 with the acronym "CHANGE". The main objective of this interdisciplinary project, is to assess, understand and monitor the modifications to which artworks are subjected over time and take cultural heritage digitization to a new level, by exploring digital datasets for deeper analysis and interpretation.

- [1] P. Schweitzer, "Fundamentals of Metallic Corrosion", CRC Press, 2007.
- [2] V. Costa, "The deterioration of silver alloys and some aspects of their conservation," *Stud. Conserv.*, vol. 46, no. sup1, pp. 18–34, 2001, doi: 10.1179/sic.2001.46.supplement-1.18.
- [3] Y. Wan, X. Wang, X. Wang, Y. Li, H. Sun, and K. Zhang, "Determination and generation of the corrosion compounds on silver exposed to the atmospheres," *Int. J. Electrochem. Sci.*, vol. 10, no. 3, pp. 2336–2354, 2015.
- [4] D. Stevens, "The effects of fingerprints on silver," *Conserv. Journal*, V&A Museum, vol. 59, 2011.
- [5] G. Ingo et al., "Indoor environmental corrosion of Ag-based alloys in the Egyptian Museum (Cairo, Egypt)," *Appl. Surf. Sci.*, vol. 326, pp. 222–235, 2015, doi: 10.1016/j.apsusc.2014.11.135.
- [6] H. A. Ankersmit, N. H. Tennent, and S. F. Watts, "Hydrogen sulfide and carbonyl sulfide in the museum environment - Part 1," *Atmos. Environ.*, vol. 39, no. 4, pp. 695–707, 2005, doi: 10.1016/j.atmosenv.2004.10.013.
- [7] P. Storme, O. Schalm and R. Wiesinger, "The sulfidation process of sterling silver in different corrosive environments: Impact of the process on the surface films formed and consequences for the conservation-restoration community," *Herit. Sci.*, vol. 3, no. 1, pp. 1–15, 2015, doi: 10.1186/s40494-015-0054-1.
- [8] T. Palomar, B. Ramírez Barat and E. Cano, "Evaluation of cleaning treatments for tarnished silver: The conservator's perspective," *Int. J. Conserv. Sci.*, vol. 9, no. 1, pp. 81–90, 2018.

### KEYWORDS

silver tarnishing | colorimetry | RTI | surface characterization

## Qualifying the perception of fineness in luxury watchmaking

Estelle Berger<sup>a\*</sup>, Estelle Leblanc<sup>b</sup>

<sup>a</sup>Strate École de Design, Sèvres, France

<sup>b</sup>Strate École de Design, Sèvres, France

\*Corresponding author: e.berger@strate.design

Perceived fineness is paramount for watch amateurs, and thus a subject of sensory perception studies for luxury brands. Those often lead to recommendations merely regarding thickness of the components. This contribution presents a 6-months project associating a French design research team and the client perception pole of a Swiss group. It aimed at enriching the understanding of fineness, so as to identify the key parameters impacting its perception and include them into an inspirational tool for watch designers. The research combined different approaches in order to address such cross-disciplinary issue, acknowledging the interdependencies between concepts, language and sensory perception.

The state-of-the-art phase allowed better qualifying the notion of fineness, with insights from multidisciplinary fields. We highlighted that it extends over an axis from pureness to refinement of details. Analogical domains allowed scoping back new sensory and/or emotional criteria into the field of watchmaking. Typography refines the grammar of lines and proportions, whereas make-up and tattoo stress out the relationship between the object and the body, oscillating between fusion and friction. This second axis was retained to study perceived fineness. In addition, contextual factors were identified: imaginary attached to each brand, male or female user, steps from seeing to wearing the watch.

Iterations supported by intermediary objects allowed to verify the relevance of the two axis and to identify a set of sensory parameters potentially impacting perceived fineness. This framework was then used for testing 12 watch models with 13 male and female watch amateurs, in a qualitative and semi-quantitative approach. Evaluators had to position each parameter on a 2-axis semantic differential scale (pureness/refinement and fusion/friction). They could also evaluate perceived fineness and qualitatively precise their feelings when seeing, touching, and wearing each watch.

Different types of results were achieved. First, the complete profile of each watch was established. Then, the impact of each parameter on perceived fineness was assessed, and correlations observed between some of them. This allowed singularizing 6 key criteria: spine, shape, weight, color, curve and rigidity. Generally, pureness and low friction are in line with high perceived fineness. Finally, the balance between parameters appears more important than any of them isolated. Consequently, design recommendations should aim at harmonization rather than optimization.

These insights led us to design a tool for the watch designers of the group, with a twofold objective. Used individually in the design studio, the device should inspire them to experiment with parameters, and feed the rationale of their choices. Used at stage-gate meetings, it should serve as a translation tool, in order to bridge the language gap frequently observed between design and marketing functions, and eventually support decision-making in the project process. The tool was designed by the design researchers' team, tested and refined with a few designers from one of the brands of the group. It takes the form of a set of 6 easel booklets, one for each of the key parameters impacting the perception of fineness. Designers' attention is drawn to the five areas created by the pureness/refinement and fusion/friction matrix. According to their positioning, each page provides multisectoral inspirational images on the front side, and watchmaking-oriented recommendations on the back.

This communication proposes to present the conceptual frameworks and methods used throughout the project, and their articulation into an abductive and iterative design research approach.

### KEYWORDS

sensory perception | perceived fineness | design research | design tool | luxury watchmaking

## Effect of Colorlite filters on colorblind observers

Luis Gómez-Robledo<sup>a</sup>, Javier Hernández-Andrés<sup>a</sup>,  
Rafael Huertas<sup>a</sup>, Miguel A. Martínez-Domingo<sup>a</sup>,  
Eva M. Valero<sup>a</sup>

<sup>a</sup>Optics Department, University of Granada, Spain

The idea of correcting Color Vision Deficiencies (CVD) through color filters goes back to 1837, with the paper of Seebeck<sup>[1]</sup>. Later on, Maxwell<sup>[2]</sup> designed a pair of spectacles for red-green CVD in 1857. Since then, many papers have deal with this idea of enriching the vision of CVD subjects by active helps. In the last times, several color filters are marketed claiming to improve some CVD [EnChroma, VINO, etc.]. However, simultaneously, many studies have been probing the limitations of these implementations, and even demonstrating the inability of any filter to overcome the CVD.

In 1998 a new set of filters, called Colorlite, were presented as another correction for CVD. This set is formed by 10 filters, divided in two groups, each one designed for protan and deutan observers. Each group contains 5 different filters intended for different color vision deficiency severities. These filters are implemented in lenses sold by optometrists, who select the proper one using a pseudoisochromatic test developed by Colorlite. This technology has also been implemented in some smart TVs as a solution for colorblindness.

Spectral transmittance of the extremal filters (corresponding to lowest and highest severities) for each set, has been measured and analyzed. The effects of these selected filters have been simulated using Lucassen's model simulate the anomalous observers' perception. This simulation has been applied to different color stimuli: Ishihara test, Colorlite test, Farnsworth Munsell test and a set of multispectral images. With these simulations it is possible to compare the effect of these filters. by the distribution of the computed colour coordinates. Besides, the number of discernible colors has been calculated for each stimulus with and without the filters as a parameter to evaluate the performance of Colorlite filters.

### KEYWORDS

color vision deficiencies | vision | color filter

## The application of color and texture of paint in the facade of Chinese Architecture—A case study on the color and texture of Shanghai Architecture

Amy Li

Akzonobel company, China  
Corresponding author: Xiaolinglily@sina.com

Paint should be the first building materials with bonding, protection and decoration functions. With the development of modern science and technology, the emergence of new materials and new processes, architectural coatings have more choices in color and texture. In addition to emulsion paint, there are texture paint, stone paint, marble paint, metal paint and so on. As one of the most common building facade materials, to a large extent, it also affects the color and texture effect of the building facade.

China is in the era of high-speed development. The process of urbanization is accelerating. The construction of new cities and the transformation of old cities are the focus of urban construction in China. Most of the construction of new buildings and the maintenance of old buildings in cities need to use architectural coatings. But how to choose the color and texture of architectural coatings to better show the style of Chinese architecture and make Chinese urban color more harmonious?

Based on the study of the color and texture of Shanghai Architecture in China, this paper summarizes the characteristics of the color and texture of building facade materials built in four different development stages in Shanghai. The architecture of these four stages is also the most representative architectural form and appearance in China at present. They are Shanghai before the opening of the port (Chinese traditional style), Shanghai during the concession period (eclectic style), Shanghai after the founding of new China (modernism style) and Shanghai in the new century (Postmodernism style). Based on the analysis of the color and texture of different building types, combined with the performance effect of modern building materials and new technology, this paper summarizes the scope and suggestions of the color and texture matching different building types in China, and provides scientific reference for urban construction in China.

### KEYWORDS

*coating & paint | architectural color | architectural texture | urban color planning*

## Fragram: A visual-olfactory experience design using odor, color and light

Nikta Arya<sup>a</sup>, Ebrahim M. Azimzadegan<sup>a</sup>,  
Bahman Ghabraie<sup>a</sup>, Maryam Khalili<sup>b\*</sup>

<sup>a</sup>University of Tehran, Tehran, BA Student in Department of Industrial Design

<sup>b</sup>University of Tehran, Tehran, Assistant Professor in Department of Industrial Design

\*Corresponding author: maryamkhalili@ut.ac.ir

The human brain has a symbolizing system for storing items in his memory, meaning a symbol is assigned to every item in order to recognize it. These associations are some forms of cross-modal correspondences such as structural, statistical and semantically- mediated reasons. Recognizing odors follows the same pattern. Odors don't have any visual elements, so people usually synthesize them with different colors, patterns, and shapes. For color-odor association and colorimetry, both perceptual and semantic factors seem to play a role; color brightness correlates with perceptual attributes of odors (odors that are more irritating and intense are associated with brighter colors) and semantic attributes (more familiar and identifiable odors are associated with more saturated colors), though the role of hedonics was also important. Indeed, the congruency of color-odor pairs is reflected in the activity of brain areas associated with the hedonics of smell. In conclusion, color influences odor identification, discrimination, intensity, and even pleasantness. The aim of this study is to review and design of a product-service system of aroma application in association with colors and light. This application called Fragram is a social network that allows users to make their own fragrance playlist for everyday use as they do now with their music player enables them to brows among different perfumes that are presented with color frames associated with the perfume. It also allows them to follow their favorite perfumers or perfume brands, search and save movie fragrance tracks or perfumes created based on books or songs in order to increase their emotional intelligence. This device creates the perfume using the capsules located beneath its stand and transmits the perfume with a chromatic light related to the odor's sense, enhancing the user's experience. This visual language of odors using digital colors increases the emotional intelligence of people and it could lead to a color categorized display in perfume shops and a tremendous change in packaging and retail industry.

### KEYWORDS

color-odor association | emotional intelligence | olfactory experience | light | social media

## The Colour Literacy Project: Proposing an Experience-Based Colour Learning Model

Maggie Maggio<sup>a\*</sup>, Robert Hirschler<sup>b</sup>, Harald Arnkil<sup>c</sup>,  
David Briggs<sup>d</sup>, Paul Green-Armytage<sup>e</sup>, Robin Kingsburgh<sup>f</sup>,  
Luanne Stovall<sup>g</sup>, Andreas Schwarz<sup>h</sup>, Stephan Westland<sup>i</sup>

<sup>a</sup>Chair, ISCC/AIC Joint Colour Literacy Project

<sup>b</sup>Co-chair, ISCC/AIC Joint Colour Literacy Project

<sup>c</sup>Aalto University, Helsinki, Finland

<sup>d</sup>Julian Ashton Art School, the National Art School and the University of Technology, Sydney, Australia

<sup>e</sup>Curtin University, Perth, Australia

<sup>f</sup>York University, Toronto, Canada

<sup>g</sup>University of Texas, Austin, USA

<sup>h</sup>University Duisburg-Essen, Essen, Germany

<sup>i</sup>University of Leeds, Leeds, UK

\*Corresponding author: maggiemaggio@gmail.com

The complex topic of «Colour» can be approached from many angles, but the academic study of colour has been relegated primarily to art education, where the information is often oversimplified, inaccurate and fossilized. Previous attempts at launching an integrated approach to the study of colour have had limited success due in part to the compartmentalization of subject areas, the high cost of materials and demonstration tools, and the lack of a broad communications network. We are now at a crossroads where colour research is expanding and technological advances in lighting, printing, computers, VR and AI are becoming an integral part of our daily lives. The time is ripe to radically rethink basic colour education by introducing an experience based colour learning model and recast colour as a collaborative arts and science subject at the elementary and secondary school level in STEAM programs and at the professional level across art, science, and industry.

This poster will present the goals and objectives of the recently formed Joint Team on Colour Literacy of the Inter-Society Color Council (ISCC) and the International Colour Association (AIC). The team is in the early stages of a four-year project to create an online, foundational colour education resource center that will be hosted by that AIC Study Group on Colour Education (SGCE) and be available for free to colour educators at all levels and across all disciplines.

### KEYWORDS

colour education | foundational concepts | STEM to STEAM

## Time-traveling colors: artisanal dreams and digital realization

Mete Kutlu

Université Paris-Est, Paris, France  
Corresponding author: metekutlu@gmail.com

How could the colors of the Ottoman miniature of the 16th century inform our understanding of architectural space in the Digital Age? This paper covers the theoretical and experimental research undertaken during two doctoral residencies, at the French Institute of Anatolian Studies in Istanbul and at the Villa Medici in Rome.

The miniaturists applied a unique set of principles to their compositions in order to represent the colors of their surrounding environment. The colors of natural pigments were used as a means to visualize imaginal transgressions of the physical space and to transfigure the perceptible world. This research begins by proposing an analysis of this phenomenon through the Ottoman understanding of color and light in its optical and metaphysical dimensions. This investigation is based on the astronomer Taqi al-Din's Book of Light, the historian Mustafa Ali's Epic of Ingenious Artists and the mystic Ibn Arabi's Bezels of Wisdom.

This paper then explains how mankind's desire to materialize such artisanal dreams of chromatic defiance gives shape to the evolution of digital information technologies. The omnipresence of digital screens creates an augmented reality in which the natural colors of starlight are juxtaposed with the digital colors of electric light. These "time-traveling colors" disrupt the modern homogenous understanding of space and reintroduce the variational dynamics that are typical of artisanal cultures of representation.

This theoretical research is combined with a process of experimentation that puts the two color systems in confrontation. In order to study the principles of chromatic and spatial representation in the miniatures, several 3D modeling programs have been used as research tools. The first experimentation is based on the transformation of architectural miniatures into origami models. Due to its miniatures offering clear views of imaginary buildings, the object of study is chosen as the divinatory manuscript *The Origin of Happiness and the Source of Sovereignty* (Constantinople, 1582). Illustrated by the imperial atelier of Osman, this manuscript is preserved at the National Library of France (BNF, Supp. turc 242).

Continuing the study of color representation at the urban scale, a miniature which depicts the Byzantine Constantinople through a mystical narrative is modeled in 3D. It is part of the eschatological manuscript *The Translation of the Key to Esoteric Knowledge* (Constantinople, circa 1600), preserved in the archives of Istanbul University (IUK, T6624, f.91b). The 3D model is transformed into an animation offering an immersive experience of the miniature space. With the use of a 3D printer, the model is then used to build a colorless physical model on which virtual textures are projected in an installation of "spatial augmented reality".

The results of this research reveal the potential of architectural design tools to mediate between historical images and museum audiences. It demonstrates the ways in which new media could be re-appropriated as iconographic research tools in digital humanities. Finally, this research seeks to forge mutually beneficial links between the disciplines of art history and architecture through the technological study of artisanal colors.

## Application and long-term durability of natural indigo on pine wood coatings and thermoplastic PLA

Juha Jordan<sup>a</sup>, Roosa Helander<sup>a</sup>, Päivi Laaksonen<sup>a\*</sup>

<sup>a</sup>Häme University of Applied Sciences, Finland

\*Corresponding author: paivi.laaksonen@hamk.fi

Synthetic dyes are commonly used for coloring consumer products such as textiles and packages. In general, dyes are designed to be very stable and thus tend to accumulate in the environment after the product is disposed. To be able to design products with good performance, but lesser environmental impact, we suggest application of natural colorants that have natural degradation routes. In this study, we investigate materials presenting applications on various time scales: a coating that should protect the surface for a long time under demanding conditions and a biodegradable plastic that is anticipated to be disposed after use. Besides conventional colorimetric and chemical analysis, we aim at developing new testing methods for coloured products employing hyperspectral imaging. As the colorant, we have chosen natural indigo extracted from woad that has been cultivated in Finland. Even though indigo is among the most used natural dyes, the Nordic indigo is a novelty product that whose industrial scale production and uses are currently under investigation.

Experiments of woad-based natural indigo for coloration of pine wood and polylactic acid (PLA) thermoplastic were carried out. The wooden samples were coated with uncolored paint using only natural indigo as the pigment and exposed to UV radiation. As reference samples, we employed synthetic indigo and commercial inorganic pigments. The changes in the color were studied and the samples were studied with hyperspectral imaging. The purpose of the experiments were to study the applicability of natural indigo in coatings in demanding conditions. Natural indigo is actually a mixture of many compounds, which may also play a role in the coating properties, such as UV stability.

Colored plastic samples were mixed from virgin polylactic acid granules and colorants through extrusion. The resulting filament was then formed into sample sticks through injection molding. All samples were exposed to cyclic UV-irradiation and condensation inside an UV-chamber. The changes in color and hyperspectra were measured in a similar way to the wood coatings. According to the obtained results, woad-based natural indigo pigment produces an even color suitable for both decorative wood coating and colored PLA filament production.

### KEYWORDS

*natural indigo | wood coatings | biodegradable plastics | spectral changes | long-term durability*



## Color and digital harmonies

Yves Charnay<sup>a\*</sup>

<sup>a</sup>Emeritus professor, EnsAD, Paris and Centre Français de la Couleur, France

\*Corresponding author: yves.charnay@free.fr

At the National Superior School of Decorative Arts, we questioned with our students about the judgment we made on the beauty of sets of colors considered harmonious. This question raised an unexpected problem: the more perfect the harmony seemed, the more doubt would arise to qualify the whole as beautiful! How can we improve the harmony of a set of colors if, paradoxically, we judge that this formal improvement does not bring the beauty that we expected?

In the framework of conferences organized at L'École Mines ParisTech we have continued experiments with students from various countries of the European community as well as Asian and in particular Chinese. We did not notice any remarkable differences in appreciation.

Creating the color charter of a city is well to organize harmoniously color sets to unify urban spaces, improve the visual appearance of a neighborhood, a set of buildings, a street ... Design as a whole seeks a visual adequacy between the plastic expression of objects and their purpose of use. In this perspective, the search for color harmonies is conceived in a limited context. To facilitate the creation of harmonious sets of color, it is useful to use digital technology. It is a universal method for easily creating harmonious ensembles. But should we question this procedure if the result does not guarantee that the sets obtained are beautiful?

Maybe such a project is too ambitious. The adequacy between the color project and the purpose of its use, can lead to satisfaction only when the application determines the agreements. In the absence of a determinant, the judgment is not sufficiently framed. It would therefore be pointless to consider symmetrically the search for beauty and the search for harmony.

### KEYWORDS

beauty | automatic | harmony

## Infrared measurement of CO<sub>2</sub> to determine post-dormant seed viability

Lev Vozchikov<sup>a\*</sup>

<sup>a</sup>Lab. Selena, Stamford, USA

\*Corresponding author: lvselena@aol.com

Infrared measurements of carbon dioxide (CO<sub>2</sub>) concentrations we can use to determine the impact of environmental pollutions on the day-night cycle of plants. Several chemical approaches are currently known. Mass determination of highway shadow-tree plants, and plant seed propagation, all involve chemical techniques to monitor CO<sub>2</sub> concentration.

Meanwhile, infrared CO<sub>2</sub> image reconstruction has studied as a method to approximate the colorant geometrical profile of vehicle emission. Here, infrared CO<sub>2</sub> image color surface reconstruction of exhaust aperture was applied to carry out thermography of dormant *Cucumis sativus* (CS), and *Lycopersicon* (LP) seeds to determine seed quality and viability. As part of biological cell respiration, exothermic chemical processes recycle carbon dioxide. During the day, plants carry out photosynthesis, and during the night, pollution can affect energy stores. Light radiance is a spectral property of atmospheric carbon dioxide gas and can be used in scalable methods to assess seed specimens. Sprouting and germination, together with thermographic testing of CO<sub>2</sub> concentration released by seed specimens, were used to generate a correlation distribution regression for post-dormant sprouting. Pregermination selection viable of *Eriogonum* (EM), Zea Mays (ZM) samples there in contingent exhibited a stable distribution seeds sprouts vigor increase.

The radiometry approach taken in this study can have broad applications for classification of seed quality as well as enhance the likelihood of selecting viable seeds from among dormant seeds. CO<sub>2</sub> distribution factors statistically analyzed along with temperature profile and length gains of sprouted seeds to allow visualization of seed readiness for germination. This CO<sub>2</sub> diffusion method was applied to compile a radiometric distribution of CO<sub>2</sub> concentration and determine viability for dormant CS and LP, EM and ZM seeds. Infrared color-CO<sub>2</sub> image contrast measurement technology based on the reconstruction of radiometric data. This research aimed to develop a nondestructive application involving contrast stimulation imaging of CO<sub>2</sub> concentration to assess the quality of dormant plant seeds.

Analysis of experimental data revealed that the concentration of released CO<sub>2</sub>, a significant factor in respiratory, metabolic processes in dormant seeds, is indicative of germination viability. This study describes an infrared colorant-gas diffusion calibration model to measure CO<sub>2</sub> concentrations. Pre-germination examination of CO<sub>2</sub> thermographic images of seed specimens offers an efficient technique for measuring seed quality, post-dormant seed viability. This unique method enables infrared imaging of dormant seed embryos to determine the likelihood of germination.

### KEYWORDS

colorant | CO<sub>2</sub> | dormant | infrared | seeds | viability

**COLOUR,  
ENVIRONMENT AND  
SUSTAINABILITY**

C65 M00 J87 N00  
R99 V180 B75

**COLOUR  
AND HERITAGE**

C65 M00 J87 N00  
R99 V180 B75

**PERCEPTION,  
CAPTATION AND  
COLOUR CREATION**

C65 M00 J87 N00  
R99 V180 B75

**DIGITAL COLOUR  
AND VIRTUAL WORLD**

C65 M00 J87 N00  
R99 V180 B75



**Book of Abstracts of the International  
Colour Association (AIC) Conference 2020**