PICS 2016

Progress in Colour Studies

Darwin Lecture Theatre

University College London

14 – 16 September 2016

Welcome

It is my pleasure to welcome you to the fourth quadrennial conference on Progress in Colour Studies (PICS). The conference was founded in the School of Critical Studies at Glasgow University by Dr Carole Biggam and the late Professor Christian Kay, and was held there in 2004, 2008 and 2012. This year we have the privilege of hosting the event at University College London (UCL), and we aim to maintain the conference's great tradition of multidisciplinarity and scholarship. Because of its origin, PICS has always been orientated towards colour systems in language, linguistics and philosophy, and this year the same themes continue to be strong. In addition we have sessions on colour in perception, imaging and design, showing the pervasive diversity of interests in colour research and application. It all seems to bear out Ruskin's assertion that "The purest and most thoughtful minds are those which love colour the most."

During these three days of the PICS conference we want to encourage curiosity about all aspects of colour, and therefore in the structuring of the single-track sessions many opportunities have been provided for reflection and debate. Oral presentations are restricted to 15 minutes, with an additional 10 minutes allocated to questions and discussion. A different set of no more than 10 posters is scheduled for each day, so that presenters can explain properly their approaches. We have an outstanding programme with four distinguished keynote speakers and many expert participants who are highly regarded in their disciplines.

I want to thank most sincerely all the members of the organising committee, who have worked together seamlessly as a team and have done such a great job in making all the arrangements: Professor Galina Paramei, programme chair; Dr Lewis Griffin, treasurer; Dr Katherine Curran, secretary; Dimitris Mylonas, media; Danny Garside, posters; and Janet Best, social. Thanks also to our supporting organisations, The Colour Group (Great Britain) and The Textile Institute, who have kindly contributed resources and promotional coverage, and to UCL for providing the venue and services.

We will continue the partnership with John Benjamins Publishing Company to produce a high quality edited publication from selected papers, as was accomplished so well by the Glasgow team following each of the previous PICS conferences. Authors will be invited to expand their abstracts to chapter length, which will then be subject to peer review.

With best wishes for a memorable conference,

Lindsay

Lindsay W. MacDonald
Chairman, PICS 2016

International Review Panel

We are indebted to colleagues from around the world who acted as reviewers of the submitted abstracts, to ensure that the highest standards were applied in the ranking and selection of papers, under the overall guidance of the programme chair, Galina Paramei:

Liliana Albertazzi
Alena Anishchanka
Harald Arnkil
Anna Bentkowska-Kafel
Seth Berriers
Janet Best
Carole Biggam
David L. Bimler
Victoria Bogushevskaya
Matthew Cranwell
Simon J. Cropper
Paula Csillag
Katherine Curran
Jules Davidoff
Vivian De La Cruz
Hilary Dalke
Maria João Durão
David Foster
Guido Frison
Caroline Gilbey
Gorm Greisen
Lewis Griffin
Angela Hart
Carole Hough
Tom Hunter
Anya Hurlbert
Kimberly A. Jameson
Clare Johnston
Ines Klemm
Jan Koenderink
Barry Lavine
Terence Leung
Lindsay MacDonald
Catherine Mafioletti
Alexis Makin
John Maule
Ray McKimm
Fiona McLachlan
Richard Misek
Dimitris Mylonas
Gabriela Nirino
Larissa Noury
Carinna Parraman
João Nuno Pernão
Alessio Plebe
Renata Pompas
Jean Pretorius
Emma Richardson
Martin Ritz
Jodi Sandford
Karl Schawelka
Karen Schloss
David Simmons
Paul Sowden
Danuta Stanulewisz
Ferenc Szabó
Elza Tantcheva-Burdge
Giorgio Trumpy
Mari Uusküla
Françoise Vienot
Christoph Witzel
Sophie M. Wuerger
Pietro Zennaro

Programme

Day #1 – Wednesday 14th September

8.30 Registration

9.45 Conference Opening: Lindsay MacDonald

10.00 **Keynote Lecture #1** Chair: Galina Paramei
Carole P. Biggam (University of Glasgow, UK) Is it all guesswork? Translating colour terms across the centuries

10.45 Coffee

Session 1: Colour Language Chair: Danuta Stanulewicz

11.15 Sandford, Jodi (University of Perugia, Italy) Cognitive entrenchment and implicit attitudes of the linguistic categories BLACK and WHITE in English

11.40 Stanulewicz, Danuta & Pawłowski, Adam (University of Gdansk, Poland) Colour and ideology: the word 'red' in the Polish press 1945-1954

12.05 Uusküla, Mari (Tallinn University, Estonia) Translation of colour terms: An empirical-cognitive approach

12.30 Bogushevskaya, Victoria (Milan UCSC University, Italy) Semantico-structural patterns of Chinese monosyllabic colour terms' development

12.55 Lunch

Session 2: Design & Fashion Chair: Janet Best

14.00 Bergmann, Christoph & Best, Janet (natific AG, Germany) Big data technology connecting supply chains driving transparency enabled sustainability

14.25 Schenk, Franziska (Birmingham City University, UK) Harnessing Nature's ingenuity: the art of 'smart' colour

14.50 Xin, John H. et al (The Hong Kong Polytechnic University) An empirical study on fabric image retrieval using colour and pattern features

15.15 Tea and **Poster Session #1**

16.15 **Keynote Lecture #2** Chair: Lindsay MacDonald
Semir Zeki (University College London, UK) Cortical mechanisms of colour vision

Session 3: Colour in Art, Pigments, Symbolism & Education Chair: Katherine Curran

16.50 Fridell Anter, Karin & Weilguni, Marina (SYN-TES Nordic Interdisciplinary Network on Colour and Light, Uppsala University, Sweden) Colour in the Pompeian cityscape: manifestations of status, religion, traffic and commerce

17.15 Wilkins, Arnold (University of Essex, UK) Colour as therapy

17.40 Wells, Kate & Greger, Ness (University of Derby, UK) Solar patterning: The employment of fast and fugitive colorants via anthotype, cyanotype and other photographic techniques

18.05 Osborne, Roy (MicroAcademy, UK) Renaissance books and colour symbolism

18.30 Reception

Day #2 – Thursday 15th September

Session 4: Colour Cognition 1 Chair: Christoph Witzel

9.00 Bangert, Thomas, et al (Queen Mary University London) Naming derived colour categories: orange, spectral purple and magenta

9.25 Bimler, David L. & Uusküla, Mari (Massey University, NZ) Mapping and comparing the conceptual organisa¬tion of colour lexicons across 14 European languages

9.50 Lillo, Julio, et al (Universidad Complutense Madrid, Spain) Spanish basic colour categories are 11 or 12, depends on the dialect

10.15 Paramei, Galina V., et al (Liverpool Hope University, UK) Diatopic variation in referential meaning of the 'Italian blues'

10.40 Coffee

11.10 **Keynote Lecture #3** Chair: Lewis Griffin
Kimberly A. Jameson (University of California, Irvine, USA) Establishing a new database resource for cross-cultural color research: the Robert E. MacLaury color categorization (ColCat) digital archive

Session 5: Development of Colour Perception and Cognition Chair: Christine Mohr

12.00 Hurlbert, Anya, et al (Newcastle University, UK) Colour naming across the spectrum: developmental disorders and colour vision deficiencies

12.25 Rogers, Marie, et al (University of Sussex, UK) The maturity of colour constancy and colour term knowledge are positively related in early childhood

12.50 Bornstein, Marc & Mash, Clay (Eunice Kennedy Shriver National Institute of Child Health and Human Development, USA) What about color attracts attention … and why?

13.15 Lunch

Session 6: Colour Cognition 2 Chair: David Bimler

14.15 Schloss, Karen B. & Heck, Isobel A. (Brown University, USA) The dynamics of color preferences: evidence from seasonal variations

14.40 Lai, Yun-Hsuan, Welch, Leslie Welch & Schloss, Karen B. (Brown University, USA) Ad hoc color concept mapping and interpreting information visualizations

15.05 Althaus, Betty, Mohr, Christine & Dael, Nele (University of Lausanne, Switzerland) Colour choices for induced joy, relaxation, fear, and sadness

15.30 Tea and **Poster Session #2**

Session 7: Colour Imaging Chair: Anya Hurlbert

16.30 Berns, Roy (Rochester Institute of Technology, USA) A spectral and colorimetric artist paint database

16.55 Watkins, Elizabeth (University of Leeds, UK) Colour and Landscape in Early non-fiction film

19.30 Conference dinner at the Hilton Hotel (London Euston)

Day #3 – Friday 16th September

Session 8: Colour Perception Chair: Karen Schloss

9.00 Forder, Lewis, et al (University of Sussex, UK) A neural signature of the unique hues

9.25 Maule, John & Franklin, Anna (University of Sussex, UK) Ensemble Perception: can humans estimate average colour?

9.50 Witzel, Christoph (Université Paris Descartes, France) The role of saturation in colour naming

10.15 Jameson, Kimberly A. et al (University of California Irvine, USA) Art, interpersonal comparisons of color experience, and potential human tetrachromacy

10.40 Coffee and **Poster Session #3**

11.40 **Keynote Lecture #4** Chair: Lindsay MacDonald
Jan Koenderink (University of Leuven, Belgium) Wayfinding in Colourland

12.25 Lunch

Session 9: Colour and Environment Chair: Joao Pernao

13.25 Garside, Danny, et al (University College London) Potential uses for spectrally variable lighting in museum environments

13.50 Hagenlocher, Esther & Smith, E. Landry (University of Oregon, USA) RED on RED

14.15 Tea

Session 10: Colour and Architecture Chair: Esther Hagenlocher

14.45 Pernao, Joao Nuno (University of Lisbon, Portugal) A phenomenological approach to colour surveys in architecture

15.10 Zennaro, Pietro (IUAV University of Venice, Italy) Strategies in colour choice for architectural built environment

15.40 Conference Close: Lindsay MacDonald

Poster Sessions Chair: Danny Garside

Posters Day #1

1. Dorn, Amelie, et al (Austrian Centre for Digital Humanities, Vienna, Austria) The colour of language! Exploiting language colour terms semantically for interdisciplinary research
2. Komorowska, Ewa & Gonerko-Frej, Anna (Szczecin University, Poland) Man and his world in colours of language (in contemporary Polish, Russian and English)
3. Loitšenko, Olga (Tallinn University, Estonia) Comparative study of colour vocabulary among Estonian-Russian and Russian-Estonian bilinguals
4. Gooby, Becky (University of the West of England, UK) Variables that affect colour in digital textile printing
5. Grobosz, Bożena (The Academy of Fine Arts, Krakow, Poland) Does color suit advanced technologies and science?
6. Mottram, Judith (Royal College of Art, London, UK) Identifying colour knowledge in design practice
7. Sagiv, Gadi (The Open University of Israel) Some notes on the colour blue in the Jewish Kabbalah

8. Bialoblocka, Karolina (Independent researcher, Poland) Paint research in Lower Silesia after 1945
9. Colson, Alicia (British Exploring Society, London, UK) A matter of life or death: identifying colour in the pictographs of the Lake of the Woods (northwest Ontario)
10. Osseiran, Shirine (Independent artist, London, UK) Colours on a 3D sculpture {Demo}

Posters Day #2

1. Dael, Nele, Althaus, Betty & Mohr, Christine (University of Lausanne, Switzerland) Overestimation of colour brightness on clothing in positive emotion expressions
2. Jonauskaite, Domicele, et al (1University of Lausanne, Switzerland) What colours do people see in fragmented vs whole versions of #The Dress?
3. Walter, Sebastian (Deutsches Archäologisches Institut, Germany) Circular yellow, blue square: results of a cross-cultural investigation of Kandinsky's colour-form combination theory
4. Wright, Oliver & Jraissati, Yasmina (Bahçeşehir University, Turkey) Color and touch: cross-modal associations
5. Almalech, Mony (New Bulgarian University, Bulgaria) Colours at tabernacle, first and second temples
6. Bourne, Alison (CBRT, UK) Use of CBRT Colour Breathing Relaxation Technique with NHS patients within an NHS primary care mental health setting {Demo}
7. Leung, Terence, et al (University College London, UK) Monitoring jaundice in newborn babies based on the sclera colour
8. Cox, Brittany & Berns, Roy (Rochester Institute of Technology, USA) Rendering 2D cultural heritage with spatially varying BRDF
9. Finlayson, Graham, et al (University of East Anglia) Colour homography
10. Finlayson, Graham, et al (University of East Anglia, UK) Computing the object colour solid using spherical sampling
11. Mehta, Beejal & Sowden, Paul (University of Surrey, UK) A systematic review and meta-analysis of evidence on whether deuteranomaly places children at a disadvantage in educational settings

Posters Day #3

1. Klarén, Ulf & Fridell Anter, Karin (Nordic Interdisciplinary Network on Colour and Light, Sweden) Common basis for colour and light studies
2. Minini, Loredana & Bangert, Thomas (University of Oxford, UK) Colour constancy: balancing primaries in extremis
3. Jarild-Koblanck, Henriette & Moro, Monica (Independent researchers, Sweden) Colours of designed nature
4. Xu, Jie (Loughborough University, UK) Local colour identities: A literature review of urban environmental colour
5. Kozlowska, Izabela & Rek-Lipczyńska, Agnieszka (West Pomeranian University of Technology, ZUT, Szczecin, Poland) Colour determined by taste of the middle class and its influence on the aesthetic image of the city and buildings in the 19th and 20th centuries
6. Kumoğlu, Özge & Camgöz Olguntürk, Nilgün (Bilkent University, Turkey) The effects of correlated colour temperature on wayfinding: a study in a virtual airport environment
7. Kwiatkowska-Lubańska, Agata (The Academy of Fine Arts, Krakow, Poland) OSCC open source colour collection for Polish interiors
8. Premier, Alessandro & Gasparini, Katia (IUAV University of Venice, Italy) Sustainable colour design in architecture: materials, technologies and products
9. Ken Devine (University of Portsmouth, UK) What colour is the sacred?

Day #1 – Wednesday 14th September

Keynote Lecture #1

Is it all guesswork? Translating colour terms across the centuries

Carole P. Biggam
University of Glasgow, UK

The study of historical colour semantics can be defined as research into the meaning of colour terms in languages and/or periods of history for which we no longer have native speakers. Typically, reactions to hearing this definition fall into one of two categories: firstly, that such research is easy or, secondly, that it is too difficult. The 'easy' group is aware that several modern colour terms are obvious descendants from ancient ones so, for example, Modern English red derives from *read* in Old English, and green from *grene*. What's the problem? The 'too difficult' group protests that the quantity and quality of surviving evidence is unlikely to provide definitions which were used in societies we only partially understand. Lacking subjects to interview, they say, we can only guess. The aim of this lecture is to show that simple, unthinking translations underestimate the difficulties but it should not be assumed that an objective approach to historical semantic research is impossible.

The main reason why historical colour terms cannot be easily translated is that forms and meanings do not necessarily change at the same rate over time. Those who happily equate ModE red with OE *read* are assuming that, because the form of the word (its spelling and/or pronunciation) has changed little in over a thousand years, its meaning must be similarly remarkably stable. It is not safe to assume this. Old English *read*, for example, can be translated as 'orange' or 'pink' as well as 'red'. It is always necessary to investigate the possibility of semantic shift, even where there is no change in spelling at all. When my grandmother said someone was 'gay' she definitely did not mean they were homosexual, yet present-day gay is spelt and pronounced in exactly the same way as she would use. In other words, in historical semantics, nothing can be taken for granted.

At the other end of the scale, it is sometimes argued that, without native speakers, all attempts to understand historical colour terms in depth are doomed to failure. While not claiming that one hundred per cent success is possible, the historical semanticist, nonetheless, has a number of research tools available which remove colour research from the realms of total subjectivity. One example of such tools may sound unlikely, namely, the study of the various colour systems in use around the world today. If a researcher embarks on a historical study expecting to find a classification of colour similar to his or her own, the results may be distorted by the lack of an open mind. Alternatively, armed with the knowledge of other systems around the world, even a small amount of evidence may be recognized as typical of a different system, such as one with fewer but more extensive abstract colour categories than our own. Anthropologists who have studied present-day macro-categories like GREEN+BLUE or YELLOW+GREEN often hold the key to better understanding an otherwise puzzling historical word. Many minority languages around the world today teach us the difficult lesson, for example, that it is possible to live happily with only a very small abstract colour vocabulary.

In attempting to reply to the two groups of critics mentioned above, I am really setting out the scope and limitations of historical colour semantics. The scope can be immense where the evidence is copious, allowing the researcher to investigate not just the descriptive values of colour terms referring to the surface appearance of an object, but also to consider their classificatory values (as with the phrase white wine which is actually yellow) or the metaphorical, connotative or symbolic senses (consider a black sheep, a black day, as black as sin and many more). Where the evidence consists of many different genres, such as newspapers, novels, poetry, letters, business documents and more, written by all social groups including a variety of occupations and ages, then the researcher has a chance to uncover even the most obscure senses associated with a colour term. On the other hand, there are limitations on colour studies where the evidence is not sufficient and/or not sufficiently representative, and there may also be problems with the documentary evidence, such as erroneous manuscript copying, damaged source material, the complications of bilingualism, and more. All these have to be studied and assessed.

Translating historical colour terms is a tricky task since the linguist, in addition to understanding languages, must also be a little bit of a historian, an anthropologist, a psychologist, an archaeologist and a sociologist. But the rewards are considerable because understanding a society's colour system augments our knowledge of that culture, revealing something of its life, literature, art and religion.

Session 1: Colour Language

Cognitive entrenchment and implicit attitudes of the linguistic categories BLACK and WHITE in English

Jodi L. Sandford
University of Perugia, Perugia, Italy

The objective of this paper is to discuss the cognitive entrenchment of the linguistic categories BLACK and WHITE in English. *Black* and *white* are considered to be achromatic in vision science and are sometimes excluded from "color" studies as such. In language, however, Black and White are considered colors. Duly, if I ask "what color it is this?" a person would respond according, "it is black", or, "it is white". At the same time *black* and *white* are tied to our embodied experience of darkness/night and lightness/day. The polar association between the concepts of BLACK and WHITE is comparable to DARK and LIGHT. They are definite aspects of our visual experience and are reflected in the significant human concerns with: lightness vs. darkness, day vs. night.; "what does seem universal, or near-universal, in the domain of SEEING is, first of all, the distinction between a time when people can see ("day") and times when people cannot see ("night")" [1]. Furthermore, these concepts are elaborated via a complex of conceptual metaphors that mark what is GOOD — KNOWING vs. NOT KNOWING, SEEING vs. NOT SEEING, LIGHT vs. DARKNESS, COLOR vs. LACK OF COLOR, MORE vs. LESS, UP vs. DOWN. This conceptualization is in keeping with KNOWING IS SEEING (GOOD IS SEEING), which represents one of our principle experiential motivations of how the mind works [2].

The implicit attitude of WHITE and BLACK with PLEASANT and UNPLEASANT are be verified through a semantic application of the Implicit Association Test (IAT) to linguistic categorization and cognitive semantics. I have tested other basic color categories RED, YELLOW, GREEN, and BLUE; and GREY and BROWN [3], [4]. The IAT is an experimental paradigm developed to study the strength of concept associations in memory [5], and to explore the unconscious roots of thinking and feeling. This paradigm has been used successfully in psychological research to understand evaluative associations involved in social categories and prejudice, discrimination, stereotypes, bias and the relation of self in society [6]. The visual categories of Black and White faces or names with a positive or negative valence have been used in IATs to evaluate racial bias [7], revealing an overall automatic preference for White relative to Black with GOOD. The semantic application of the IAT is able to indicate a participant's conceptual default attitude toward a given, in this case, *linguistic* category. The IAT paradigm measures automatic affect or implicit attitude through a double discrimination task that maps four categories onto two responses. The IAT verifies speed and the facility of categorizing the stimuli of each category to a same response key: e.g. BLACK and UNPLEASANT vs. WHITE and PLEASANT, or the opposite. Each conceptual category includes eight items that are divided equally between positive and negative connotations; it is essential that the stimulus items not permit alternate interpretations of category. This study employs two parameters of evaluation: the IAT effect and the *D* measure. The difference in reaction time to the categorization grouping of *compatible* and *incompatible* associations shows the IAT effect. This semantic use of the IAT test (Inquisit software) concentrates on linguistic categorization and primary conceptualization in a usage base approach of elicited responses, thereby revealing cognitive entrenchment [8] of semantic color relations as they vary according to association.

I hypothesize that the categorization responses be consistent with other IATs favoring LIGHT over DARK, with WHITE more compatible with PLEASANT, rather than BLACK. A second IAT tries to reverse the attitude by weighting the associated objects BLACK with positive and WHITE with negative connotations.

References

[1] Wierzbicka, A. (1996). Semantics Primes and Universals. Oxford University Press: Oxford.

[2] Lakoff, G. - M. Johnson (1999). Philosophy in the Flesh. New York: Basic Books. pp. 393-397.

[3] Sandford, J.L. (2016). Cognitive Entrenchment of Color Category Associates and Implicit Attitudes in English, *Colour Language and Colour Categorization,* Cambridge Scholar Publishing: Newcastle upon Tyne.

[4] Sandford, J.L. (2015). The Implicit Association in English of the Semantic Categories BROWN and GREY with PLEASANT, Italian Color Association. *Colour and Colorimetry Multidisciplinary Contributions, XI B,* 289-301.

[5] Greenwald, A.G. - D. McGhee - J. Schwartz (1998). Measuring individual differences in implicit cognition: The Implicit Association Test. *Journal of Personality and Social Psychology,* 74, 1464-1480.

[6] Greenwald, A. G. - B. A. Nosek - M. R. Banaji (2003). Understanding and using the Implicit Association Test: I. An improved scoring algorithm. *Journal of Personality and Social Psychology, 85,* 197-216.

[7] Nosek, B. A. - M. R. Banaji - A. G. Greenwald. (2002). Harvesting intergroup implicit attitudes and beliefs from a demonstration Web site. *Group Dynamics, 6(1)*, 101–115.

[8] Langacker, R. W. (2008). Cognitive Grammar: A Basic Introduction. Oxford University Press: New York.

Colour and ideology: The word for red in the Polish press 1945–1954

Danuta Stanulewicz[1], Adam Pawłowski[2]
[1] University of Gdańsk, Gdańsk, Poland
[2] University of Wrocław, Wrocław, Poland

In the evolutionary sequences proposed by Berlin, Kay and their co-workers, the term for red holds a special position. In the 1969 model it is the first word for a chromatic colour to join the colour lexicon [1], whereas in the 1999 model Kay and Maffi emphasize its primacy: it is one of the first names of chromatic colours to emancipate ([2], see also [3]).

The symbolism of red is rich. Red has been symbolically linked to life, war, power and love, to name but a few [4]. In Neolithic Europe, red ochre was used for funerals, and red ribbons are still believed to protect people and domestic animals from dangerous diseases in some cultures [5]. This colour is also associated with communism. Anna Wierzbicka claims that its prototypical references are blood and water [6]. This is supported by the findings of another study: on the ranking list of associations, blood occupies the first position and fire – the second [7]. Red is also the most ambivalent colour as it strongly evokes both positive and negative associations [8]. As far as emotions are concerned, it is associated mainly with anger and aggression as well as with love and anxiety [9].

The aim of this paper is to investigate the use of the Polish term for this colour, *czerwony*, in the press released in 1945-1954. We will extract the data from ChronoPress (Chronologiczny Korpus Polskich Tekstów Prasowych (1945-1954)), a corpus of Polish newspapers and magazines available at <http://clarin.pelcra.pl/chronopress/#>. At this moment, the number of words in the corpus amounts to *ca*. 10,100,000 (the corpus will be expanded to include 17,700,000 words). The number of the occurrences of *czerwony* in the corpus is now 2143 (in 2050 paragraphs).

We would like to investigate the uses of *czerwony* in the historical context of the new political system, communism, introduced in Poland after World War II. As has already been mentioned, red is one of its symbols. We will analyze collocations with *czerwony* as well as its connotations. Doing so, we will be able to estimate the percentage of ideologized uses of this lexeme. We will also take into consideration the frequency and use of other basic colour terms employed in the texts compiled in the corpus. Finally, we will compare the uses of *czerwony* in the texts of ChronoPress with its occurrences in the press in the later years, included in the National Corpus of the Polish Language (Narodowy Korpus Języka Polskiego), available at <http://nkjp.pl>.

We would like to add that although the Polish terms for red have been analyzed from various perspectives by a number of scholars (including, *int. al.*, [10-13]), no corpus analysis of these terms has been carried out, let alone their use in newspapers and magazines published in Poland in the first years following the end of World War II.

References

[1] Berlin, B, Kay, P, (1969). *Basic Color Terms: Their Universality and Evolution*. Berkeley: University of California Press.
[2] Kay, P, Maffi, L, (1999). Color appearances and the emergence and evolution of basic color lexicon. *American Anthropologist, 101/4,* 743-760.
[3] Biggam, C P, (2014). Prehistoric colour semantics: A contradiction in terms. In: Anderson, W, Biggam, C P, Hough, C, Kay, C (eds.). *Colour Studies: A Broad Spectrum*. Amsterdam – Philadelphia: John Benjamins, 3-28.
[4] Kopaliński, W, (2007 [1990]). *Słownik symboli*. Warszawa: HPS, Rzeczpospolita.

[5] Komorowska, E, (2010). *Barwa w języku polskim i rosyjskim: Rozważania semantyczne*. Szczecin: Wydawnictwo Naukowe Uniwersytetu Szczecińskiego.
[6] Wierzbicka, A, (1996). *Semantics: Primes and Universals*. Oxford: Oxford University Press.
[7] Stanulewicz, D, (2009). *Colour, Culture and Language: Blue in Polish*. Gdańsk: Wydawnictwo Uniwersytetu Gdańskiego.
[8] Stanulewicz, D, Komorowska, E, Pawłowski, A, (2014). Axiological aspects of Polish colour vocabulary: A study of associations. In: Anderson, W, Biggam, C P, Hough, C, Kay, C (eds.). *Colour Studies: A Broad Spectrum*. Amsterdam – Philadelphia: John Benjamins, 258-272.
[9] Mozolewska, A, (2010). Colour terms and emotions in English and Polish. *Beyond Philology, 7,* 77-102.
[10] Ampel-Rudolf, M, (1994). *Kolory: Z badań leksykalnych i semantyczno-składniowych języka polskiego*. Rzeszów: Wydawnictwo Wyższej Szkoły Pedagogicznej.
[11] Benenowska, I, (2010). Wybrane orzeczenia syntetyczne – wykładniki predykatów nabywania koloru czerwonego. In: Komorowska, E, Stanulewicz, D (eds.). *Barwa w języku, kulturze i literaturze* I. Szczecin: Volumina.pl Daniel Krzanowski, 31-49.
[12] Tokarski, R, (2004 [1995]). *Semantyka barw we współczesnej polszczyźnie*. Lublin: Wydawnictwo Uniwersytetu Marii Curie-Skłodowskiej.
[13] Zaręba, A, (1954). *Nazwy barw w dialektach i historii języka polskiego*. Wrocław: Ossolineum.

Translation of colour terms: an empirical-cognitive approach

Mari Uusküla
Tallinn University, Tallinn, Estonia

How to translate *lemon*, *salmon*, *coral* and other colour terms derived from object names into different source languages? How to translate different language- or culture-specific colour terms, e.g. Italian *azzurro* or *glicine*? Is it possible to distinguish between original and translated colour terms? Does the translation process itself change something, namely does the source language affect the usage of a target language? Do professional translators and non-trained individuals differ in offering translations of colour terms?

In order to answer to above questions, colour term translation was studied in two genealogically and typologically different source-target language pairs – English–Estonian and Italian–Estonian. Italian–Estonian translation tasks included linguistically complex culture-specific colour terms, e.g. *celeste*, *amaranto*, *verde Veronese*, etc., whereas English colour terms were all derived from object names, e.g. *amber*, *chocolate*, *fuchsia*, etc. Additionally, a colour-naming task with 80 Munsell colour ships originally selected for the Evolution of Semantic Systems project was carried out [1]. While colour terms in linguistics and psycholinguistics form a well-established area of research, colour term translation has received little or no attention and calls for development. This contribution adds new knowledge to the field of translation studies [2], [3].

The empirical-cognitive approach was conducted with two different conditions for the two language pairs. In the first, so-called word-translation task, participants were requested to translate twenty context-free colour terms into their native language, whereas in the other task they were asked to translate the whole sentences containing one or more colour terms (a context-related condition). The English–Estonian sample consisted of 20 participants (15 F, mean age 30.9). All were native speakers of Estonian with different backgrounds. This group also performed a colour-naming task after two translation tasks. The Italian–Estonian sample consisted of 20 participants (17 F, mean age 29), all native speakers of Estonian. Half of the participants in both groups were experienced translators or had obtained translation education.

The results confirmed the hypothesis that colour terms used in the colour naming task were different from the ones used in translation task, which confirms the different nature of original and translated texts. In the translation tasks certain translation strategies or patterns occurred: e.g. basic colour term in the source language was translated by using an equal basic colour term in the target language; some source language/culture specific colour terms were preserved, while others were substituted; culture-specific colour terms in the source language were sometimes converged with the target culture and language, causing contextual or metaphorical changes; some participants applied descriptive translation techniques by adding a commentary or a footnote, etc. Experienced translators and participants with translation training performed better in the translation tasks; they were able to translate faster and followed the sentence structure of the source language. Moreover, experienced translators offered more creative translation solutions. Gender differences could not be discerned due to small male sample, but intriguingly, age, education or knowledge of other languages had no comparable impact on the translation outcome.

References

[1] Majid, A., Jordan, F., Dunn, M., (2015). Semantic systems in closely related languages. *Language Sciences*, *49,* 1–18.

[2] Chesterman, A. (2000). *Memes of translation: the spread of ideas in translation theory.* Amsterdam; Philadelphia: Benjamins.

[3] Li, Z. (2011). A study on cognitive models in colour term translation between English and Chinese. *International Forum of Teaching and Studies*, *7 (1)*, 49.

Semantico-structural pathways of Chinese monosyllabic colour terms' development

Victoria Bogushevskaya
Università Cattolica del Sacro Cuore, Brescia, Italy

The making of silk in China—the birthplace of sericulture—can be traced to approximately 3630 BCE; the art of using natural dyes developed along with the creation of new textiles. The surviving examples of Western Zhōu 周 (1046–771 BCE) silk reveal high level dyeing techniques with vegetable and mineral dyes, with painting and embroidery decorations. By the Warring States Period 戰國 (475–221 BCE), ancient Chinese had already fully mastered multi-layered dyeing techniques.

However, the colour lexicon in pre-imperial and early imperial China was not sufficiently developed to convey all the nuances of obtainable shades. This task was not fulfilled by China's oldest preserved comprehensive character dictionary, the *Shuōwén jiězì* 《說文解字》 (Analytical Dictionary of Characters) (ca. 100 CE) either. This is, simply because *any* term—including a colour term—is always an abstraction, and abstractions and generalisations do not remain intact, they *themselves* are the product of social and cultural development.

The Chinese writing system is logographic, where each character represents a word or a morpheme. This is why the first criterion for a colour term to be basic, suggested by B. Berlin and P. Kay (1969/1991), applied to Chinese, requires the following modification: a term should be *monomorphemic* and moreover *monosyllabic*—rather than just *monolexemic*—seeing that almost every syllable is a morpheme in Chinese.

The tree distinguished categories that are pertinent in colour term assessment include the following: 1) the phonosemantic, where a character consists of the phonetic part and the semantic determiner (henceforth 'DET') that specifies the semantic domain of the corresponding word; 2) the syssemantic, where the Chinese characters' meaning is indicated by the combined meanings of their constituent parts; 3) the pictographic category, where the semantic node of the written sign is attached to the semantics of a word by way of some degree of conventionalized iconicity.

The data for the present study were elicited from etymological and explanatory dictionaries, classical texts and anthologies. Through a structural and semantic analysis I was able to determine the following patterns of monosyllabic colour term emergence:

1. Semantic extension of lexemes that originally denoted:
   a) plant dyes and mineral dyes (e.g., *dān* 丹 'cinnabar' → 'red');
   b) natural objects or artefacts of certain colour (e.g., *huī* 灰 'ashes' → 'grey');
   c) dyed fabrics (e.g., *hóng* 紅 'the silk fabric dyed with red and white dyestuffs' → 'pink');
   d) characteristic colours of certain natural objects that became semantico-phonetic elements and act as secondary semantic nodes, while the exact meanings of these newer lexemes are specified by DET (e.g., *zhū* 朱 'a tree from the stem of which is drawn some red pigment' → 'bright red' → *zhū*絑 [DET 'thread'] 'the colour that [undyed] silk cloth acquires after being immersed four times in red dye', *zhū* 袾 [DET 'cloth'] 'red jacket', *zhū* 硃 [DET 'stone'] 'cinnabar').

2. Doublets of monosyllabic lexemes:
   a) phonetic doublets of dyes (e.g., *qiàn* 茜 'madder' was used to obtain *qiàn* 綪 'dark-red silk');

b) semantic doublets: syssemantic-category characters formed by reduplication of the earlier colour terms (e.g., *chì* 赤 'red' → *hè* 赫 'fiery red');
c) semantic doublets with the use of earlier colour terms as DET (e.g., *dān* 丹 'red' → *tong* 彤 'vermillion');
d) contextually restricted phonosemantic doublets (e.g., *lí* 驪 'black' (of mammal hair, DET 'horse') → *lí* 黎 'black' (of people's hair) → *lí* 黧 'blackish-yellow' (of complexion or of hair, DET 'black').

The process of Chinese colour terms' development can be expressed not only by the semantic relation 'the object and its characteristic colour quality', but also by the relation 'the quality and the process of its acquiring'.

References

[1] Baxter, William H. III., (1983). A look at the history of Chinese color terminology. *Journal of the Chinese Language Teachers Association XIX. 2*, 1–25.

[2] Behr, Wolfgang, (2009). In the interstices of representation: ludic writing and the locus of polysemy in the Chinese sign. In *The Idea of writing: Play and complexity*, edited by A. de Voogt and I. Finkel, 281–314. Leiden: E.J. Brill.

[3] Berlin, Brent and Paul Kay, (1969/1991). *Basic color terms: their universality and evolution*. Berkeley: University of California Press. Second edition.

[4] Gao, Hanyu. 高汉玉，(2001). Zhongguo xianqin yizhuang yanliao secai yu wenhua 中国先秦衣装颜料色彩与文化 [The Dye Colours and Culture on Clothing in the Pre-Qin period]. In *The polychromy of antique sculptures and the Terracotta Army of the First Chinese Emperor.* Wu Yongqi, Zhang Tinghao, Michael Petzet, Erwin Emmerling, Catharina Blänsdorf eds., 114–125. München: ICOMOS.

[5] Jaxontov S.E., (1965). *Drevnekitajskij jazyk [Old Chinese].* Moskow: Nauka.

[6] Maréchal, Chrystelle 麦里筱，(2003). Hanyu yanse lei ci de chansheng 汉语颜色类词的产生 [Development of the terms related to "colour" in Chinese]. *Gu hanyu yanjiu 4*, 60-65.

[7] Needham, Joseph, (1974). *Science and Civilization in China. Vol 5: Chemistry and chemical technology. Part 2: Spagyrical discovery and invention: magisteries of gold and immortality.* With collaboration of Lu Gwei-djen. Cambridge: Cambridge University Press.

[8] Pan, Feng 潘峰, (2004). Erya shiqi hanyu yanse cihui de tezheng 《尔雅》时期汉语颜色词汇的特征 [Characteristics of the *Erya* time colour lexicon]. *Hubei chengren jiaoyu xueyuan xuebao 3.10.2*, 27–30.

[9] Schuessler, Axel, (2007). *ABC etymological dictionary of Old Chinese*. Honolulu: University of Hawai'i Press.

[10] *Shuowen jiezi jin shi 說文解字今釋* [Modern explanation of the *Shuowen jiezi*]. Compiled by Tang Kejing 汤可敬，(2001). 2 Vols. Changsha: Yuelu shushe.

[11] Vainker, Shelagh, (2004). *Chinese Silk: A Cultural History.* New Jersey: Rutgers University Press.

[12] Wang, Tao, (2007). Shang ritual animals: colour and meaning (part 1). *Bulletin of SOAS 70.2*, 305–372.

[13] Wenren, Jun, (2013). *Ancient Chinese encyclopaedia of technology: translation and annotation of the Kaogong ji (the Artificers' Record).* NY: Routledge.

[14] Xu, Chaohua 徐朝华, (2003). *Shanggu hanyu cihui shi. 上古汉语词汇史*. [History of Archaic Chinese lexicon]. Beijing: Shangwu yinshuguan.

[15] Yao, Xiaoping 姚小平, (1985). Gudai han minzude yanse guannian 古代汉民族的颜色观念 [The concept of colour among the ancient Han]. *Baike zhishi* 6, 25-27.

[16] Ye, Yun, Lynn G. Salmon and Glen R. Cass, (2000). The ozone fading of traditional Chinese plant dyes. *Journal of the American Institute for Conservation 39.2,* 245–257.

[17] Zhang, Xian, Good, Irene and Laursen, Richard, (2008). Characterization of dyestuffs in ancient textiles from Xinjiang. *Journal of Archaeological Science 35*, 1095-1103.

Session 2: Design & Fashion

Big data technology connecting supply chains driving transparency enabled sustainability

Christoph Bergmann[1], Janet Best[2]
[1]natific AG Switzerland
[2] natific AG UK

Colour is one of the most valued features of any textile, it is well documented that colour drives sales and profitability and that the application of colour is an energy, chemical and resource hungry process. Ongoing progress is being made to reduce environmental impact of dyes, chemicals, water and energy used at specific process level. These are island solutions and as such soon reach their optimum impact. However repeating any process twice no matter how efficient is not supporting a sustainable environment. Only when you have good processes and supply chain partners all connected with transparency can the next level of progress and sustainability be achieved and maintained.

This research investigates and measures cloud computing big data from transparent connected global manufacturing supply chain partners. To quantify specific improvements to effectively break the cycle of repeat processing. Through intensive data analysis of the fashion industry supply chain case studies of brands, garment makers, vendors, dyers and trims suppliers, clear patterns can be seen for improvements directly correlated to the degree of connected transparency. The adjustments to traditional colour management behaviours have most impact and directly contribute to reduced production lead times, improved final colour quality and significant reduction of resource consumption and waste.

Harnessing nature's ingenuity: the art of 'smart' colour

Franziska Schenk
Birmingham City University, Birmingham, UK

With 'smart' colour as focus, this interdisciplinary paper presents relevant findings from the material sciences, optical physics and evolutionary biology as vehicle to demonstrate and highlight the intricate linkages between the sciences and the arts. It is argued that the emerging scientific field of biomimetics has the potential to facilitate artistic innovation, most notably in the domain of colour - while simultaneously providing novel rules for creative application. Tracing the origin of biomimetics back to the ancient concept of mimesis (defined by Aristotle as 'imitation of nature' via both form and material), the emphasis is on latest bio-mimetic colour-technology – and its potential, for the first time, to mimic the full spectrum of nature's colours in art.

Colour as dramatic, dynamic and dazzling as the iridescent hues on the wings of certain butterflies has, for example, never previously been encountered in the art world. Unlike and unmatched by the chemical pigments of the artists' palette, these changeable hues are created by transparent, colourless nanostructures that, as with prisms, diffract and reflect light to render spectral colour visible. Until now, iridescent shades, by their very nature, have eluded and defied artists' best efforts to fully capture these rainbow colours. However, here the author illustrates how, via scientifically studying the ingenious ways in which a range of such displays are generated in nature, she arrived at vital clues on how to adapt and adopt these challenging optical nano-materials for painting [1, 2]. Eventually, after years of meticulous and painstaking research both in the lab and the studio, she achieved the desired effect [3, 4]. The resulting paintings, like iridescent creatures, do in fact fluctuate in perceived color - depending on the light and viewing angle (Fig. 1). Tracing the author's unique biomimetic approach, this visual, vividly illustrated, account affords an insight into the new colour technology's evolution. Together with innovative artistic possibilities, the paper advocates that – both for scientists and artists – there continues to be much learned from nature.

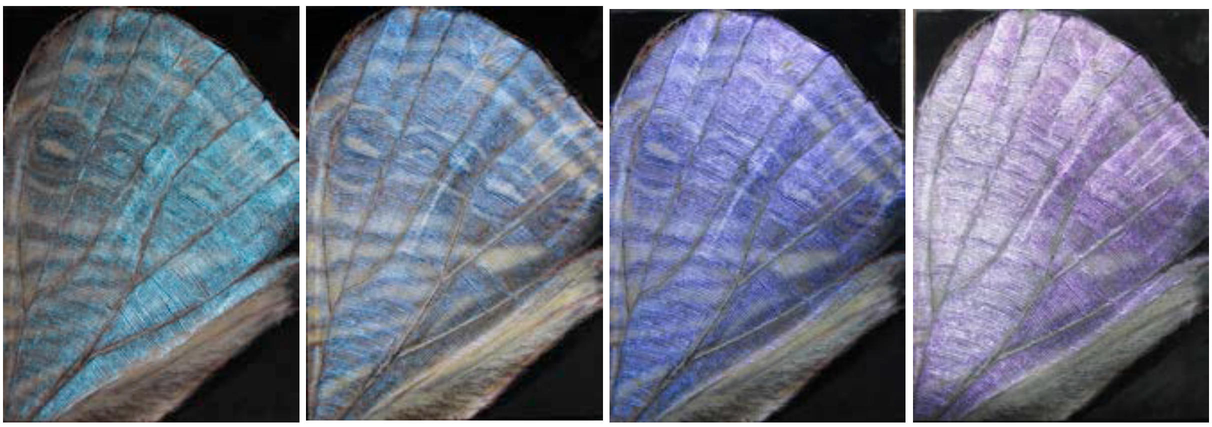

Figure 1. Franziska Schenk ©, Morpho wing, nanopaint on board, A4-size, 2013. The same painting photographed various times to demonstrate colour change, depending on light and viewing angle

References

[1] Schenk, F, (2009). Nature's Fluctuating Colour Captured on Canvas?, *Int. J. of Design & Nature and Ecodynamics, Vol. 4, No. 3,* 274-284.

[2] Schenk, F and Parker, A, (2011). Iridescent Colour: From Nature to the Painter's Palette. *Leonardo, Vol. 44, No. 2*, 108-115.

[3] Schenk, F, (2015). Biomimetics, Color and the Arts. *Proc. SPIE 9429, Bioinspiration, Biomimetics, and Bioreplication, 94290Z*, doi: 10.1117/12.2084302.

[4] Schenk, F, Wilts, B and Stavenga, DG, (2013). The Japanese Jewel Beetle: A Painter's Challenge. *Bioinspiration & Biomimetics, 8, 045002*, 10pp.

An empirical study on fabric image retrieval using colour and pattern features

H.C. Wu, P.P. Yao, S.J. Shao, John H. Xin
The Hong Kong Polytechnic University, Institute of Textiles and Clothing, Hong Kong

Introduction

Content-Based Image Retrieval (CBIR) System draws a lot of attention in recent years due to the emergence of large-scale image collections. Instead of being manually annotated by text-based key words, images would be indexed by their own visual content, such as colour and texture. Many techniques in this research direction have been developed and many image retrieval systems, both research and commercial, have been built (Rui et al., 1999).

Fabric image retrieval has been studied recently with difference indexing and classification schemes on woven fabrics (Zhen et al., 2009). Many image features such as global and local features are used for improving the accuracy represent the content of fabric images (Huang et al., 2013). Different types and fabrics images such as lace have also been studied (Zhang et al., 2015). This study empirically compares the effects colour and pattern features on yarn-dyed and printed fabrics. Specially, four retrieval models are implemented and tested for retrieval effectiveness comparisons on a database containing 2,100 fabric images. Among the four retrieval models, three of them use colour features of images while the other three use pattern features.

Retrieval Methods

A retrieval model serves the purpose of defining the (1) representation of the data and (2) the search mechanism (i.e., the matching function). Generally, in CBIR, the images are represented as high-dimensional feature vectors. The features can be extracted using colour information, texture information or pattern information contained in the images. For the matching function, a distance measure is used such as the Euclidean distance measure or the Cosine Similarity measure. Among the four implemented retrieval models, three of them are colour-based retrieval models which make use of the colour information in the images while the other one makes use of the pattern information in the images.

The first model using colour information is based on the first two statistical moments of the colour intensities in an image. For each of the channels of a colour space, the first two statistical moments (i.e., the mean and the standard deviation) of the intensities are computed and used as a feature representing an image. Therefore, a three-channel colour space will have six features (i.e., two features per channel). For each of the images in the database, it is divided into grids of 4 regions. For each of the 4 regions, six features are extracted. As a result, an image is represented with a 24-dimensional feature vector based on the statistical moments of colour intensities. The Euclidean distance is used for computing the dissimilarity between two images.

The second model using colour information is based on the MPEG-7 Dominant Colour Descriptor (Wong and Po, 2004) which finds the dominant colours in an image. While the third one is based on matching the Pantone colours found in an image.

In pattern-based retrieval models, local pattern features of an image are extracted. The features are referred as SIFT key-points (Lowe, 1999) in an image. An image is represented as a Bag-of-Features (BoF) model in which every key-point is assumed to be independent with each other. The model is adopted from the well-known and successful Bag-of-Words (BoW) models in the text information retrieval literature (Sivic, 2009).

Experimental

The retrieval performance (average precision, average recall and average reciprocal rank (RR) is computed for each of the implemented models on the tested database containing 2,100 fabric images (Figure 1). The results are shown in Table 1.

Figure 1. Example Fabric Images in the Database

Table 1: Summary of performance of the four implemented retrieval models.

Model	Feature	Avg. Precision	Avg. Recall	Avg. RR
SIFT	Pattern	.7384	.8846	.8942
Pantone	Colour	.3024	.4552	.4784
Dominant	Colour	.3857	.6031	.6120
Basic Statistical	Colour	.6238	.8571	.9166

From the results, the pattern-based SIFT model performs the best among all the four models according to precision and recall. The basic statistical model (i.e., considering the mean and standard deviation of colour intensities) performs the best among the colour-based models. It is also the best among all when compared using Reciprocal Rank (RR).

Conclusion

This empirical study shows that pattern feature is important for fabric image retrieval on yarn-dyed and printed fabrics. The results are consistent with other works in the literature (e.g., Huang et al., 2013) and extend on a larger database which contains 2,100 fabric images. Future works include considering other pattern features and also texture features of fabrics.

References

[1] Rui, Y; Huang, TS; Chang, SF 1999, Image Retrieval: Current Techniques, Promising Directions, and Open Issues. Journal of Visual Communication and Image Representation, vol. 10, pp. 39-62.
[2] Wong, KM; Po, LM 2004, MPEG-7 dominant color descriptor based relevance feedback using merged palette histogram. IEEE International Conference on Acoustics, Speech, and Signal Processing, vol.3, pp. 433-6.
[3] Zheng, D; Baciu, G; Hu, J 2009, Accurate indexing and classification for fabric weave patterns using entropy-based approach. 2009. IEEE Int. Conf. on Cognitive Informatics (ICCI'09), 357-364.
[4] Huang, X; Chen, D; Han, XH; Chen, YW 2013, Global and local features for accurate impression estimation of cloth fabric images. IEEE Int. Symposium on System Integration, pp. 486-489.
[5] Zhang, L; Liu, X; Lu, Z; Liu, F; Hong, R 2015, Lace fabric image retrieval based on multi-scale and rotation invariant LBP. ACM Proceedings of the 7th International Conference on Internet Multimedia Computing and Service. pp. 1-5.
[6] Lowe, DG 1999, Object recognition from local scale-invariant features. In Proceedings of the International Conference on Computer Vision. pp. 1150–1157.
[7] Sivic, J 2009, Efficient visual search of videos cast as text retrieval. IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 31, No. 4, pp. 591–605.

Keynote Lecture #2

Cortical mechanisms of colour vision

Semir Zeki
UCL Research Department of Cell and Developmental Biology
Faculty of Life Sciences, University College London

It is perhaps useful conceptually to separate a discussion of the cortical mechanisms of colour vision from the retinal ones. In this talk, I will argue that what we have learned about the cortical mechanisms underlying colour vision could not have been (and was not) predicted from the vast amount of work done on retinal mechanisms. These include the strong dependence of colour upon inherited brain programs that generate constant colours, the role of adscititious factors in generating colours, and of what mechanisms underlie colour opponency. The new insights gained from a study of cortical mechanisms involved in colour must be ultimately integrated with the knowledge derived from studies of retinal mechanisms underlying colour vision.

Session 3: Colour: Art, Pigments, Symbolism & Education

Colour in the Pompeiian cityscape: manifestations of status, religion, traffic and commerce

Karin Fridell Anter[1], Marina Weilguni [2]
[1] SYN-TES Nordic Interdisciplinary Network on Colour and Light, Sweden
[2] Department of Archaeology and Ancient History, Uppsala University, Sweden

Roman Pompeii was buried by the eruption of Vesuvius in AD 79. This paper presents part of a larger project, dealing with its streets and open public spaces. We here concentrate on the colours of facades, pavements and monuments.

Sources and method
The source material regarding Pompean facades is sparse and diverse. In our field studies we found that very little of the ancient facade material and colouring remains to be seen. Thus we have largely relied on other sources:
- Reports from original excavations (1748-1983) and recent re-excavations. Mostly, facade appearance is hardly mentioned, with an important exception in Vittore Spinazzola's excavations of *Via dell'Abbondanza* (Fig. 1)
- A cork model at the Archaeological Museum in Naples, showing the excavated town in 1879.
- Artistic reproductions
- Ancient and recent literature on Roman building materials, techniques and pigments, architecture and town planning.

Our analysis started from Spinazzola's documentation and compared it to the rest of the material, to see to what extent his conclusions would be valid also for other streets than *Via dell'Abbondanza*.

Figure 1. Via dell'Abbondanza, from [1]

Materials and pigments
Most facades were plastered and at least partly painted, mostly with lime wash. The now visible multicoloured brick facades were most often hidden behind plaster. A few facades had visible tufa stone (subdued yellowish) and even fewer exhibited white or light coloured marble. Streets were mostly paved with dark grey lava blocks, with kerbstones of lava or yellowish grey limestone. Those sidewalks that were paved showed beige-greyish stone mixture or pinkish brick crush in mortar, or sometimes elaborate patterns of different stones. Most of the many public water fountains were made of lava. Statues and other monuments showed white and multi-coloured marble and were partly painted in vivid colours. Painting of facades was mostly made with cheap and durable earth pigments, offering a colour range of yellow – red – brown – subdued greenish. Black was made from soot or burnt ivory, and white was inherent in the lime wash. More vivid, and more expensive, mineral pigments could be used for details or very exclusive objects.

Colour and city structure
Spinazzola's paintings from *Via dell'Abbondanza* show buildings with varied and strong colours; often red up to 1,5 – 2 meters height and whitish above that, with many painted images and messages on the walls and with wide openings to shops or workshops. We found that this probably characterised also other thoroughfares with much commerce, but that streets with other functions had distinctly other colour characters: The Forum and its nearest neighbourhood was singled out by white stone paving and grand buildings with light coloured marble or imitation-marble stucco, lacking the vividly coloured lower zones. There was also a clear distinction between streets with elaborated front sides of large houses, and whitish or even unpainted alleys behind the same houses. The colouring of different types of streets could serve as a guidance for visitors, including the vehicular traffic. Those few water fountains that had light colours could function as indicators, and even more so a number of white stones near the Forum, clearly raised to block traffic and to ensure that this fact was understood even from a distance.

Building colours
The choice of colours, features and materials seems to indicate status and wealth, without distinction between buildings with different functions or between private and public ones. Light facades with real or imitated elaborate stone work indicated high status, and for the coloured lower zones black and yellow showed more status than the more common red. When construction boundaries did not coincide with ownership boundaries there was a tendency to express ownership irrespective of construction, creating a uniform front for houses with different age and original style that now had the same owner. We found no efforts to express the house uniformly in all directions.

Colours along the street
Pictures on the facades served as signs for shops and workshops. Many shops also announced themselves by the activity itself, for example fast food places with solid counters clad with multicoloured marble. Small reliefs on the facades were originally painted in vivid colours. Often they show phalluses and have therefore been wrongly understood as marking brothels – they should instead be interpreted as bringers of fertility and good luck. Street-shrines were common and often placed in smaller alleys, near the crossing with a main street. Typically they had paintings on white background. Apart from all this there were probably painted colours on the wooden doors and window shutters that were definitely destroyed by the volcano eruption.

[1] Spinazzola, V. (1953). *Pompei. Alla luce degli scavi nuovi di Via dell'Abbondanza (Anni 1910-1923)*. Roma, La Libreria dello Stato.

Tinted lenses as therapy

Arnold Wilkins
University of Essex, Colchester, UK

The Intuitive Overlays are coloured filters that can be laid upon a page when reading, so as to colour the text beneath. They provide a range of 30 colours that sample chromaticity systematically. The clinical response to these filters is used as guide as to the advisability of an assessment for tinted glasses. These can be provided by a system for precision ophthalmic tinting launched in 1993 and subsequently established in UK optometric practice. A coloriser (Intuitive Colorimeter) illuminates a page of text with coloured light and permits the separate manipulation of hue and saturation at constant luminance. The hue and saturation are adjusted to find a colour that reduces perceptual distortion and discomfort. The system permits the selection of an optimal colour when the eyes are colour-adapted. The colour is reproduced under conventional white lighting using a set of coloured trial lenses with various depositions of seven dyes. Only two dyes with neighbouring chromaticity are used. The chosen tinted trial lenses guide the dyeing of spectacle lenses. The system provides tinted spectacles with spectral transmission designed to minimise metamerism, having a chromaticity that is a suitable compromise between that optimal under daylight and that optimal under incandescent light. Coloured overlays and precision tints have been assessed in the treatment of a variety of neurological conditions, including dyslexia, migraine, autism, multiple sclerosis, stroke and photosensitive epilepsy. We will review the conditions and assess the reported benefits.

In many studies of the use of overlays by school children, a minority reliably show improved reading speed with the overlay chosen as optimal for clarity. It is difficult to rule out placebo effects, given the children chose the overlay they used. A variety of controls have been used but the best control uses a double-masked design. A study with such a design was possible using tinted spectacles. Children who regularly used coloured overlays for reading, many with reading difficulty, took part. The colorizer was used to select an optimal colour that reduced perceptual distortion and discomfort and a sub-optimal colour that was just sufficiently different to allow distortions and discomfort to occur. Spectacles matching each colour were worn for four weeks in random order. Conditions of colour adaptation in the colorizer prevented participants identifying the pair of spectacles with the optimal tint. Although the symptoms were reduced with the optimal tint more than with the suboptimal, the study was marred by high rates of attrition.

The ophthalmic tinting system was also used in a double-masked study of adults with migraine. The reduction in symptoms of eye-strain and headache was lower with the optimal tint than with the suboptimal but the sample size was small and the effects were marginal.

In a later study the system was again used to obtain an optimal and suboptimal tint for migraine patients but in this study the patients observed gratings in a fMRI scanner. The amplitude of the BOLD response was compared when the gratings were observed with the optimal tint, with a tint of suboptimal colour, and with a grey tint of similar transmission. The abnormal oxygenation of the brain in migraine patients was normalised with the optimal tint, but not with the other tints.

The oxygenation of the brain in migraine patients was also measured in a subsequent study but this time with near infrared spectroscopy. Again the abnormal oxygenation was normalised with the optimal tint but not with the suboptimal or grey tints.

In two studies, coloured filters placed upon the page improved the reading speed in a high proportion of children with autism spectrum disorder. Their perception of emotion in facial expression was more accurate with individual tints in a study that used a two-alternative forced choice protocol.

In computational models of the visual cortex, the visual stimulation that gives rise to perceptual distortions and discomfort has been shown to result in non-sparse and excess neural activation. This is consistent with the large haemodynamic response that uncomfortable visual stimuli elicit. It has been proposed that the discomfort is a homeostatic mechanism to reduce hypermetabolism and associated energy costs. If this is the case it is interesting that the amplitude of the haemodynamic response has been shown to increase with the colour differences in an image. Tints reduce such differences (overall), and might for this reason reduce discomfort and hypermetabolism. Such a viewpoint is insufficient to interpret the individual differences in colour chosen, but might begin to explain some of the clinical benefits with which coloured filters are occasionally associated.

Solar patterning: the employment of fast and fugitive colorants via anthotype, cyanotype and other photographic techniques

Kate Wells, Ness Greger
University of Derby, College of Arts, UK

This paper discusses on-going research into natural dyes, mineral dyes (Lake pigments or raised colours) and leuco-vat dyes (Inko and SolarFast) with the potential to create a sustainable method of patterning fabric that employs the light sensitivity and fastness properties (fast or fugitive) of the colorants in creating a permanent (photographic) image in colour upon natural or re-generated fibre base.

Instigated by the output of collaborative research between two different disciplines: that of textile design and early colouration methods with historical photographic imaging techniques. The project initially considered the symbiotic relationships between natural plant extracts had with 'Anthotypes' [1] and raised colours specifically 'Prussian blue' had with 'Cyanotypes' or 'Blue prints' [2] under different application techniques and light exposure sources. The aim of which, was to understand the success or failure of these types of photographic processes known today under the heading of 'Alternative photography' (Figure 1.) and consider the question: Could this kind of photographic image making be applied as a future, sustainable method of design generation, colouration and patterning of fabric for fashion and interiors? The objective was to create an alternative sustainable surface design process that relies upon light and natural colouring substances/dyes as the main patterning and processing medium.

Figure 1: Cyanotype of Periwinkle and Anthotype of Blackberry

The main aim of the research was to combine collaborative design practice with a scientific technical approach in understanding the reasons: Why and How do Cyanotypes and Anthotypes work? Their correlation with sunlight, ultraviolet and infrared light in relation to quality and colour of images achieved on exposure; in combination with the fastness properties of natural dyes/substances employed within the process. By looking at the substantive and fugitive properties of the colouration materials, analysis was made into which colorants are the most successful and reliable for future use.

Followed was an investigation into the relationship of natural colours both their fastness and fugitive properties (Figure 2.) and those of mineral dyes (lake or raised colours) have in enabling the success of creating a positive image with these early photographic techniques. In order to establish a clear method of how to manipulate the differing light fastness of natural dyes, literary searches were carried out with Patricia Crews [3], Gill Dalby [4] and David Lee [5] recording extensive research regarding methods and techniques and rated many natural dyes based on their light fastness qualities.

Figure 2: Fast and fugitive mixing and basic fastness testing.
Madder with Blackberry, Madder with Turmeric, Woad with Blackberry

Their studies show that although the majority of natural dyes fade at differing rates when exposed to natural daylight there are a handful of natural dyes that show a strong light fastness, these include Madder, Indigo and Woad. Therefore the mixing of these light fast dyes with fugitive dyes can potentially create a larger colour palette that changes over time with a fugitive secondary colour fading to reveal a fast base colorant. These findings were then applied to dyestuffs to be employed, using sustainable fabric bases for the creation of an eco textile design process. The colour extractions were applied to a substrate through different coating and dyeing techniques and allowed to dry before imagery, as photograms or acetate positives, based upon the plant material the colouration solutions had been extracted from was then exposed to different light sources: daylight, the visible spectrum as well as ultraviolet and infrared light which act as catalysts to the fading process, with some dye stuffs fading at the blue end of the spectrum and others within the yellow/red wavelengths.

Although some very successful outputs were achieved; the main disadvantage of this technique being sustainable being that the fugitive colorant that provides the photographic image/design continues to fade with light and time. New investigations lead to an improvement in fastness once a design has been created, with recent research carried out into the different solubility of colouring materials touched upon by Hubble [6] and expanded upon by Lee [7] with developments in application of the colouring matter as well as methods for enhancing the light fastness after exposure and patterning by applying an after-mordant such as Iron or Copper acetates to the Anthotypes after exposure or as other research has revealed the application of UV blockers such as vitamin C, [8] lemon and lime juice that does not normally affect the colour of the patterning produced.

References

[1] Fabbri, M. (2011) *Anthotypes: explore the darkroom in your garden and make photographs using plants*. Stockholm: M. Fabbri, Alternativephotography.com

[2] Ware, M. (2014) *Cyanomicon: History, Science and Art of Cyanotype photographic printing in Prussian blue*. Buxton: www.mikeware.co.uk. Accessed: 30 January 2016.
http://www.mikeware.co.uk/mikeware/downloads.html

[3] CoxCrews, P. 1982. *The Influence of Mordant on the Lightfastness of Yellow Natural Dyes.* Faculty Publications - Textiles, Merchandising and Fashion Design. Paper 7. Accessed: 30 January 2016. http://digitalcommons.unl.edu/textiles_facpub/7.

[4] Dalby, G. 1985. *Natural Dyes, Fast or Fugitive*. England: Ashill Publishers.

[5] Lee, D. (2007) *Nature's palette: the science of plant color*. 1st edn. Chicago: University Of Chicago Press.

[6] Hubble, J. (1885) *The Dyeing of textile fabrics.* London: Cassell & Company Ltd.

[7] Cristea, D and Vilarem, G. (2006) Improving light fastness of natural dyes on cotton yarn. *Dyes and Pigments.* 70: 238e245. Accessed: 30 January 2016. www.elsevier.com/locate/dyepig.

Renaissance books and colour symbolism

Roy Osborne
Thylesius Books, London, England

A dozen books were published on colour symbolism during the sixteenth-century. Two of the most original were Gilles Corrozet's *Le Blason des couleurs en armes, livrées et devises* (1527) and Pellegrino Morato's *Del significato de' colori* (1535). The first primarily presented contemporary symbolism and the second primarily catalogued colour symbolism from antiquity. After 1600, remarkably few new publications appeared on the subject until the esoteric booklets of the early 1900s, some of which influenced expressionism in art, before such symbolism was absorbed by psychology. The presentation briefly examines the contents of such books and how attitudes to colour symbolism evolved.

Poster Session #1

The colour of language! Exploiting non-standard language colour terms semantically for interdisciplinary research

AmelieDorn[1], EvelineWandl-Vogt[1], Jack Bowers[1], Thierry Declerck [2]
[1]Austrian Centre for Digital Humanities, Austrian Academy of Sciences, Vienna, Austria
[2]German Research Centre for Artificial Intelligence, DFKI GmbH, Saarbrücken, Germany

1. Introduction – the project exploreAT!

This paper describes the exploitation of colour terms for interdisciplinary research. The study is part of a larger collaborative project, *exploreAT!*[1][1], carried out at the Austrian Centre for Digital Humanities. The project itself explores the richness of the German language, in particular the *Bavarian dialects in Austria*, in the area of the former Austro-Hungarian empire. It is based on the *Dictionary of Bavarian dialects in Austria* (WBÖ) and the *Database of Bavarian dialects in Austria* (DBÖ). The extensive collection of 20th century dialect data for dictionaries, was harvested by means of questionnaires (~ 20,000) with answers noted on hand-written paper slips containing around 200,000 individual headwords in about 3.5 million individual records. Having undergone different stages of digitisation, the dialect data is currently being encoded in TEI/XML [2] working towards linked open data, mapping onto RDF [3] and making use of Ontolex [4,5]. Being embedded in the EGI ENGAGE [6]/DARIAH-CC[7] infrastructures, interdisciplinary access is supported. The digital structures and data modelling open up our data to a wide range of interdisciplinary areas that work with colours or colour terms, and allow querying and access to information also to third parties. In the Digital Humanities context, the data are explored from the perspectives of lexicography, digital infrastructure, visualisation and citizen science. The wealth of available information not only covers dialectal words, but also valuable cultural information about the country and its people [8], and colours are one particular part of it. In this paper we provide first insights into the different angles of exploitation of colour terms, in particular semantic aspects, in the context of the project, the wider European infrastructures, and potentials for related interdisciplinary perspectives.

2. The data – questionnaire on colours and beyond

Questionnaire number 53 (*Farben*) "Colours", is dedicated to colour terms, and serves as the starting point for the data analysis. It contains around 100 individual questions asking for specific names, synonyms, sayings related to particular colours or traditional beliefs or customs as shown in the examples below.

```
53D10 grün: der Grünling, Grüner, Grünler (Name von Tieren, Menschen, Pflanzen)
```

[53D10 green: der Grünling, Grüner, Grünler (name for animals, humans, plants)]

```
53C1 rot: rot, Wendungen, Vergleiche; Vkdl.: Zauberfarbe!, z.B. rote Halsbänder (Schellenbögen) bei Kälbern
```

[*53C1 red: red, phrases, comparisons; popular belief: magic colour!, e.g. red neckband for calves*]

[1]ηττπ://ωωω.οεαω.αχ.ατ/αχδη/δε/εξπλορεΑΤ [αχχεσσεδ: 20 Αυγ 2016]

Colours covered include *white, yellow, red, blue, green, brown, yellow-brown, grey, black* as well as *pale* and the term *colour* itself. Interestingly, answers do not only contain information on colours, but dip into a variety of other semantic fields in other questionnaires including animal and plant names, food, diseases or the use of colours for specific customs and festivities. Mark up for etymological information and semantic concepts is offered using standards such as TEI[2], thus linking various sources. Our mapping of the lexicographic data onto RDF follows also the intention to be able to represent those interdependencies using the linked open data (LOD)[9] means. With the aid of digital humanities tools it is envisaged to analyse these data in terms of connected semantic concepts and linguistic formation. In addition, information on location, time and source of entries are considered, contributing to the application of visual analysis tools, where analysis is currently on the way.

3. European frameworks and contexts

The cross-linguistic and cross-cultural differences in colour terminology have been well and widely studied, cf. [10]. The data described here are also integrated in larger European frameworks and initiatives that the *exploreAT!* project is connected to the Network of electronic Lexicography (COST ENeL) [11], where colour terms are part of recent projects on etymological dictionaries[3], and where work is carried out towards a European Dictionary Portal [12]. As to European infrastructures, the project data is also embedded in the frameworks EGI ENGAGE and DARIAH CC, which enable the link to several other data types, and the discovery of content of digital repositories via semantic search engine. This is another key element in making these data accessible to other disciplines.

4. Conclusion and outlook

In this paper we gave an initial insight into the exploitation of colour terms for interdisciplinary research. With the aid of Digital Humanities tools, the data is opened up to analysis from various perspectives. With the applied data model and the additional development of visual analysis tools and the integration of citizen science, access on a variety of levels to scholars and non-scholars alike is provided. Access to these non-standard data is also supported in wider European infrastructures.

References

[1] Wandl-Vogt, E., Kieslinger, B., O´Connor, A. & Theron, R. (2015): „exploreAT! Perspektiven einer Transformation am Beispiel eines lexikographischen Jahrhundertprojekts“, in: *DHd-Tagung 2015*. Graz. Austria http://dhd2015.uni-graz.at/de/nachlese/book-of-abstracts/ [accessed: Oct, 30th 2015].

[2] Schopper, D., Bowers, J. & Wandl-Vogt, E. (2015) dboe@TEI: remodelling a database of dialects into a rich LOD resource. *TEI. Text Encoding Initiative. Conference and Members Meeting 2015*, Lyon. France. http://tei2015.huma-num.fr/en/papers/#146 [accessed: Oct, 30th 2015].

[3] Resource Description Framework - RDF http://www.w3.org/RDF/ [accessed: Nov 1st 2015]

[4] Wandl-Vogt, E. &Declerck, T. &Mörth, K.H. (2015) Towards a Pan European Lexicography by Means of Linked (Open) Data. *Proc. eLex2015*, Herstmonceux Castle, UK, pp.342-355.https://elex.link/elex2015/proceedings/eLex_2015_22_Declerck+etal.pdf [accessed 14.2.2016]

[2] www.slideshare.net/JackBowers1

[3] COST ENeL WG4: European Roots https://sites.google.com/a/campus.ul.pt/european-roots/home

[5] Christian Chiarcos, Philipp Cimiano, Thierry Declerck, and John P. McCrae (eds). *Proc. of the 2nd Workshop on Linked Data in Linguistics (LDL-2013), Representing and linking lexicons, terminologies and other language data*, September 23, Pisa, Italy, CEURS, 2013.

[6] EGI ENGAGE -https://www.egi.eu/about/egi-engage/ [accessed 14.2.2016]

[7] DARIAH CC -https://wiki.egi.eu/wiki/Competence_centre_DARIAH [accessed 14.2.2016]

[8] ImmateriellesKulturerbe - ÖsterreichischeUnesco

http://immaterielleskulturerbe.unesco.at/en/ [last accessed Oct 30th 2015]

[9] Linked Open Data - LOD see http://linkeddata.org/

[10] Deutscher, G. (2010) Through the Language Glass. How Words Colour Your World. London: William Heinemann.

[11] COST IS 1305: European Network of electronic Lexicography (ENeL) www.elexicography.eu

[12] Dorn, A., Villalva, A., Giouli, V., Blanck, W., Kovalenko, K. &Wandl-Vogt, E (2016) Displaying Language Diversity on the European Dictionary Portal - COST-ENeL-Case Study on Colours and Emotions and their cultural references. *EURALEX2016*, Tbilisi, Georgia.

Colour terms expressing emotions and physiological states: a comparative analysis of Polish, Russian and English fixed phrases

Ewa Komorowska, Anna Gonerko-Frej
University of Szczecin, Poland

The aim of our paper is to compare fixed phrases containing colour terms in three languages, Polish, Russian and English. We will concentrate on the expression of emotions and physiological states. We adopt a semanto-cultural approach in the analysis of the collected data. The investigated phrases describe domains such as outward appearance, emotions, intellect, views etc. Apart from dictionary entries, we will analyze examples from Polish, Russian and English literature and language corpora as well as from transcripts of everyday conversations. We believe that the data will not only demonstrate the rich multicolour palette used to describe human beings, their lives and emotions, but also allow us to present a broad range of frequently poetic ways of expressing meanings. It will also enable us to analyze similarities and differences between the three languages.

The analysis of the collected material concentrates on basic colour terms and words for different shades. Special attention will be drawn to various connotations of colour terms determined by historical and cultural differences. In Polish, for example, the term for red has a primary connotation of love: its expression and symbol (the heart). [1, 2] In Russian, the term for red is mostly associated with the revolution and Bolsheviks or bloodshed, e.g. *Красная армия* 'Red Army', *Красный флаг* 'Red Flag', *красный уголок* 'meeting place of members of organizations of young people' (in communist times), lit. 'red corner'. [3] The love connotation is secondary, whereas in Polish the political meaning comes the second (*czerwoni* 'the red'). The English reference to debt or bureaucracy (*in the red*, *red tape*) is unfamiliar to both Slavic languages.

Our analysis focuses on the functioning of colour terms in the domain of emotional states where numerous colour terms appear, from words for various shades of red (purple, red, pink) through yellow and green, to grey and white (e.g. *zżółknąć w chorobie* 'to become yellow because of an illness'; *biała twarz ze strachu* 'white face with fear'; *spurpurowieć na twarzy ze złości* / *zdenerwowania* / *zawstydzenia* 'to become purplish red in the face because of anger / irritation / shame'; *позеленеть на лице от гнева* 'to become green in the face because of anger'; *покраснеть от радости* 'to become red with joy'; *побледнеть от страха* 'to become pale with fear'). [1. 2, 3] The differences in the meanings of similar phrases will be discussed, e.g. Russian *жёлтый дом* 'lunatic asylum', lit. 'yellow house', *жить в жёлтом доме* 'to stay in a lunatic asylum', contrasted with a similar Polish phrase, *mieć żółte papiery* 'to be insane', lit. 'to have yellow papers'. [1, 3] Similar expressions may have different meanings, e.g. Russian *серый человек* 'grey man/person' describes a simple, uneducated, uncultured person and Polish *szary człowiek* 'grey man/person' is understood as a common person, without any hints to his/her intellect, with emphasis on the fact that his/her sad everyday existence makes him/her an insignificant member of society. [1, 2, 3]

Another aspect of our study is contextual dynamics in the description of outward appearance (*zaczerwienić się* 'to redden'; *стать бледным как смерть* 'to become pale as death'), emotions (*żółć się w kimś przelewa* 'somebody is angry', lit. 'gall (=yellow) is pouring in someone'; *кровь кипит от злости* 'blood is boiling because of anger'). We also include an analysis of the expression of colour space, in particular, the degree of colour spread. [1] Phrases can refer to the colour of focal points (*czerwony nos* 'red nose'; *красные уши* 'red ears'); dispersed points (*czerwone plamy na twarzy ciele* 'red spots on the body'; *красные пятна на лице* / *кожи* 'red spots on the face / skin'; *покраснеть пятнами на лице* 'to get red spots on the face'); spread over a certain area (*twarz* *zalana czerwienią* ‘reddened face’ lit. ‘face flooded with the red colour’; *лицо залилось красной краской* ‘the face blushed’, lit. ‘the face was flooded with the red colour’) or spread towards extreme points (*zaczerwienić się po czubek nosa* ‘to become red to the tip of the nose’; *покраснеть до ушей* ‘to become red to the ears). [1] We also take into consideration the associations of colours with temperature. We can talk about high temperatures using words for red (somebody’s skin may be *red with fever* or *emotion*) or low temperatures when one is cold due to weather conditions, e.g. *skóra sinieje* / *bieleje* ‘the skin is getting blue / white’, an illness or emotions such as fear, e.g. *sine usta* ‘blue lips’; *grey face*; *biała twarz jak ściana* ‘white face as a wall’ etc.

References

[1] Komorowska E., (2010). *Barwa w języku polskim i rosyjskim: rozważania semantyczne*. Szczecin.

[2] Tokarski R., (1995). *Semantyka barw we współczesnej polszczyźnie*, Lublin.

[3] Кульпина В. Г., (2001). *Лингвистика цвета: Термины цвета в польском и русском языках*. Москва.

Comparative study of colour vocabulary among Estonian-Russian and Russian-Estonian bilinguals: preliminary study

Olga Loitšenko
Tallinn University, Tallinn, Estonia

This research aims to record a colour vocabulary of two types of bilinguals living in Estonia - the Estonian-Russian (ER) and Russian-Estonian (RE) bilinguals. The main research questions are: 1) Do ER or RE bilinguals use a colour vocabulary that is more similar to the one used by Estonian or Russian monolingual speakers respectively, with an emphasis to the blue (and purple) categories? 2) Are bilinguals using more Estonian colour terms in Russian (translations) or Russian colour terms in Estonian or is there a third common variety of ER and RE bilinguals' colour terms?

The field method by Ian Davies and Greville Corbett [1] is implemented using the colour-naming task and the list task. The colour tiles used for the research belong to the Ostwald's colour system. There are 65 colour tiles used as stimuli in the colour-naming task. The tiles are covered with coloured paper from the Color-aid Corporation's 220-sample set [2] [3] [4]. The aforementioned method was applied in researching basic colour names in both Estonian [5] and Russian [1] languages, which provides the data used for comparing the colour vocabulary of the ER and RE bilinguals with the Russian and Estonian monolingual speakers' colour vocabulary. Both of the tasks are conducted in Russian and Estonian.

The research by Davies and Corbett [1] showed that the respondents differentiated between *sinij* 'dark blue' and *goluboj* 'light blue'. Galina Paramei has proposed that Russian blues are different in meanings, thus the naming situation changes usually when the objects or substances that are blue in colour are referred to [6]. Both *sinij* and *goluboj* could be considered context restricted. The differences may occur depending on the culture that the native speaker belongs to (see Frumkina [7]). Mari Uusküla [8] found in her research that the speakers in all Finno-Ugric languages used modifying adjectives (especially those which correspond to the English light and dark) to clarify the exact colour shade of a sample, while English and Russian speakers did not. Thus it can be assumed that the respondents who are more fluent in Estonian might have been influenced more by the Estonian culture and vice versa with the respondents who are more fluent in Russian.

The preliminary results show, that half of the participants named the colour *goluboj* 'light blue' in a listing task and more than half named the aforementioned colour in a naming task. Participants, who named the colour name *goluboj* were in majority RE bilinguals. Only one ER bilingual named the colour in a naming task, likewise in Estonian the colour name for the same colour tiles, for majority of the participants was *helesinine*, which stands for light blue.

[1] Davies, I, and Corbett, G, (1994). The basic color terms of Russian. *Linguistics 32*, 65–89.

[2] Uusküla, M, (2006). Distribution of colour terms in Ostwald's colour space in Estonian, Finnish, Hungarian, Russian and English. *Trames: Journal of the Humanities and Social Sciences*, *10* (2), 152−168.

[3] Uusküla, M, (2014). Linguistic categorisation of blue in Standard Italian. In: Wendy Anderson, Carole P. Biggam, Carole Hough and Christian Kay (Ed.). Colour Studies: A Broad Spectrum, Amsterdam/Philadelphia: John Benjamins, 67−78.

[4] Bimler, D, and Uusküla, M, (2014). “Clothed in triple blues”: Sorting out the Italian Blues. *Journal of the Optical Society of America A : Optics, Image Science, and Vision*, *31* (4), A332−A340.

[5] Kalda, T, (2014). Soomlaste, eestlaste ja Soomes elevate eestlaste v’rvileksikoni võrdlev analüüs. [Comparative analysis of the colour lexicon of the Finnish, the Estonians and the Estonians living in Finland]. Master Thesis. Tallinn University.

[6] Paramei, G, (2005). Singing the Russian Blues: An Argument for Culturally Basic Color Terms. *Cross-Cultural Research*, *39*(1), Sage Publications, 10–34.

[7] Frumkina, R, M, (1999). What does my eye tell your mind? *Behavioral and Brain Sciences*, *22*, 951–952.

[8] Uusküla, M, (2006). Distribution of colour terms in Ostwald’s colour space in Estonian, Finnish, Hungarian, Russian and English. *Trames: Journal of the Humanities and Social Sciences*, *10* (2), 152−168.

Variables that affect colour in digital textile printing

Becky Gooby
University of the West of England, Bristol, UK

The development of digital printing is a major change within the textile design process as a designer is no longer restricted to number of colours, repeat patterns, and may include photographic images and intricate detail. With digital print it is now possible to print anything between a metre, or hundreds of metres, at the click of a button. However, there is a marked difference between screen-colour and print-colour. A textile designer using Computer Aided Design (CAD) to create a design will be required to experiment with a number of variables in order to feel more confident about the outcome when using digital fabric printing. There are already various software, materials and printers involved in digital textile printing which impact on colour results. Additionally, fabric choice and secondary processes (washing and steaming) contribute to colour variation. The poster charts these variables and outlines the affects they have on printed colour. Variables include, but are not limited to: fabric, ink, software, printer, profile applied and secondary processes (washing, steaming).

Does color suit advanced technologies and science?

Bożena Groborz
Jan Matejko Academy of Fine Arts in Krakow, Faculty of Industrial Design, Poland

The history of fashion and clothing is inseparably linked with color trends. For centuries different meanings have been attributed to colors and symbolism and associations are present in our cultures up until this day. Technological advancement in the field of manufacturing of fabrics and clothing affected trends creation and development. Employing synthetic dyes in production caused that it was incomparably cheaper to manufacture color fabrics which also became more available for society. For that reason one had to invent uniforms that would distinguish between the dame and regular maid.

In the 20th Century color fabrics were already widely available. However nowadays there is a tendency of going back to what we have started with, it is very common that luxurious and expensive clothing are rather scanty in colors while wildly colored clothing is reserved for those of unsophisticated taste and for clothing that can hardly be called modern. Such designers as Giacomo Balla and Fortunato Depero, Sonia Delaunay and Raymon Loewy in the Thirties, Paco Rabanne and Rudi Gernreich in the Seventies emphasized combination of science and lab work creating a vision of the fashion of the future. The 21st Century does not emphasizes, it acts, linking laboratories with clothes making industry, chemical engineers, electronic engineers, microbiologists and nanotechnology experts with cloth designers, tailors and couturiers.

It is not a surprise that new technological possibilities put traditional methods of clothes making out to pasture. Experimenting with new technologies, especially by students and young fashion designers, impacts color diversity of their designs. It would be probably correct to say that vision of modernity and sophistication for majority of fashion designers equals switching from chromatic to achromatic colors. White, black and various shades of grey are probably most favored colors and innovation is focused on methods of shaping and structuring the fabric together with utilization of 3D printing technique.

Slightly bit more color one can observe in case of designs incorporating source of color light. This is another type of designs widely used by students and next technological novelty that affects color side of projects. Despite of the fact that possibilities in the area of „luminescent fabrics" are incredible, designs produced with use of this technique are not as colorful as one could think. And here comes a question – cannot modernism be colorful? Doesn't color suit advanced technologies and science?

This presentation will not provide a clear-cut answer. It only presents observations of the author based on selected projects that link clothing with high-tech technologies and scientific novelties.

Identifying colour knowledge in design practice

Judith Mottram
Royal College of Art, London, United Kingdom

The multiple disciplinary fields with an interest in colour studies presents an environment where there may be both agreements and misconceptions about how different domains understand colour. In response to a discussion with a psychologist about the curriculum for students undertaking practical degrees in the visual arts, this paper aims to explore the different foci of expert knowledge within creative disciplines. While the 'teaching' about practical and perceptual elements of artistic practice and reception has, at least in the UK, become downplayed in relation to the emphasis given to process, strategy and criticality, colour theory and practice still constitutes a part of many textile design undergraduate programmes.

This project explores current knowledge and understanding about colour by a respondent group (n=40) of Textiles Masters students at the Royal College of Art, London. The postgraduate student community is drawn from many nationalities, including American, Chinese, Russian, Turkish and Thai, giving a range of prior experience and cultural specificity. The intention is to provide a platform for further studies on nomenclature, systems of visualisation or specification, and preference. These are topics which have been addressed from linguistics, technology and psychology [1, 2, 3], but there is little systematic work from within creative disciplines. The premise is that by looking more closely at contemporary disciplines in which the application of colour is part of creative practice, we might usefully gain insights that could inform the orientation of future work in adjacent fields.

An artist is defined as someone who paints, draws or makes sculpture. A designer plans how something can be fabricated. Art works and designs have properties, of which colour is one distinguishable by vision. Whilst seemingly so fundamental, the UK Quality Assurance Agency Benchmark does not reference colour within the skills, knowledge and capabilities expected in study at Undergraduate level. [4]

The survey explored levels of colour understanding and when knowledge of colour was acquired by respondents, through schooling, later study or other means. We found colour knowledge was largely acquired before the age of twelve. Respondent evaluations of the importance of colour and their confidence in using it are higher than their professed levels of knowledge of colour theory.

There were two main elements to the survey. Respondents were asked to describe their colour palette, to list colours they regularly used in design, to list those they tended to prefer, and those they disliked. The second major element of the survey explored familiarity with eleven colour system terms and thirty-one terms used to describe colours in the blue-green dimension as used in several different art and craft arenas (artists pigments, ceramic glaze colours and natural language). The colour term dimension was constrained to blue-green to focus the study.

The data generated from the questions is considered in relation to previous preference studies. [5] There is indication of preference leading use, and of not using preferred colours. The language terms used tend towards basic colour terms and some descriptive references. There were some surprises in unfamiliar colour names, which may reflect the diverse backgrounds of the respondents. The range in ways to describe some specific colour samples to different audiences confirms the challenge for specification and variability in perception among this fairly expert group, who will be moving into a professional arena where a core practice will be working with clients, customers and manufacturers on designs for inherently coloured goods.

This initial study concludes there are distinct palette types apparent among the respondents. There is evidence in respect of colour usage of a light/dark axis with a set of distinct hues, and alternately a more colour-orientated palette punctuated with one or two neutral notes. In respect of preference, the palettes are defined more narrowly. Disliked colours are still more specific, and in some place no dislikes are expressed.

A follow-up study will be conducted after the respondents have completed a series of colour seminars, a colour project, and additional project and self-directed practice. In parallel, a series of discussions with professionals in the relevant industrial sectors plans to explore their practices and expectations in colour specification. The findings are anticipated to contribute to clarification of whether there are emerging challenges in preparing the next generation design workforce for decision-making and specification in global marketplaces and a starting point for further collaborations with other disciplines working in colour studies.

References

[1] Wierzbicka, A. (2006). The Semantics of Colour: A New Paradigm. In Pitchford, N.J. & Biggam, C.P. (Eds.), *Progress in Colour Studies: Volume I. Language and Culture* 1–24. Philadelphia: John Benjamins Publishing Company.

[2] MacDonald, L. W. (2006). *Digital Heritage: Applying Digital Imaging to Cultural Heritage*. Oxford: Elsevier.

[3] Palmer, S. E., Schloss, K. B., & Sammartino, J. (2013). Visual aesthetics and human preference. *Annual Review of Psychology*, 64: 77-107.

[4] Quality Assurance Agency (QAA) (2008). The UK Quality Code for Higher Education Subject Benchmark Statements, Subject benchmark statement: Art and design. Available from: http://www.qaa.ac.uk/en/Publications/Documents/Subject-benchmark-statement---Art-and-design-.pdf (accessed 25 January 2016)

[5] Hurlbert A, Ling Y. (2012). Understanding colour perception and preference. In: Best, J, ed. *Colour Design: Theories and Applications*. Oxford: Woodhead Publishing Limited, 129-157.

Some notes on the colour blue in the Jewish Kabbalah

Gadi Sagiv
The Open University of Israel, Raanana, Israel

The colour blue is often considered enigmatic and ambiguous. Across various cultures and time periods, it has been attributed diverse—and sometimes opposite—meanings and functions. In some instances, blue signified sacredness, like the blue garment in images of Virgin Mary. In other cases, it resonated with danger when associated with demonic entities, such as the devil or the barbarians.

In Judaism, the colour blue plays a special role; it is actually the only colour required in everyday Jewish ritual. References to blue in Jewish religious texts can be found primarily in Jewish legal literature that discusses in detail the usage of that colour in Jewish ritual. Yet significant references to blue can also be found in texts of Kabbalah, the Jewish mystical and esoteric tradition. These references were hardly studied.

This study explores the under-researched special role of the colour blue in texts of Kabbalah. It shows that kabbalistic texts integrate symbolism, magic, myth, and ritual to construct a concept of the colour blue that was later adapted and applied in various cultural settings.

By investigating the history of the construction, transformation, and reception of a particular colour among Jews and its relationships with phenomena beyond Judaism, this study is expected to contribute to the broader scope of research of histories of colours in religion.

Architectural paint research in Lower Silesia after 1945

Karolina Białobłocka
Visiting Researcher at TU Berlin, Germany

The following paper discusses examinations of historical colours that took place in the Lower Silesia region during the years 1945 – 2014[1]. The scientific analyses of architectural finishes from all over the world have been discussed so far in scattered articles and conference proceedings[2]. However, the issue of architectural paint research in Lower Silesia have never been comprehensively addressed. In fact, it was only the mid-1990s when paint research has started to become an instrumental part of the examinations of Silesian monuments prior to their refurbishment. Before that time paint research was very rarely conducted on buildings in Lower Silesia.

In terms of research methodology, archival research was identified in order to explore architectural paint research. Records of paint examinations stored in the following archives of the Monument Offices were investigated: MKZ Wroclaw, WKZ Wroclaw, WKZ Legnica, WKZ Jelenia Góra, WKZ Walbrzych and in WKZ Opole. Surveys conducted in the Silesian archives in the years 2010-12 revealed in total two hundred and seventy-seven documents recording paint research on exteriors and only several more on interiors[3] [1].

The paint examinations discussed in the paper were conducted in different ways. Apart from the methods used, the scope and method of documentation also differed, since each time an examination was specified by different people – not only conservators conducting those examinations but also public officials, architects and investors. For these reasons they are burdened with different degrees of accuracy and error.

A few problems were tackled in the paper including the methodology of paint research, an interpretation of discovered facts, the manner of documentation, the manner of describing colours. In conclusions selected problems were indicated and a few suggestions were made to be considered in the future pain research.

This study may enable the improvement of historic paint analyses in Lower Silesia and contribute towards the recently raised necessity to agree on standards in the way samples are taken, analysed and recorded; thereby allowing us to preserve better original polychromes and, as a result - monuments closer to their original state.

[1] Białobłocka, K, (2014). *Colour schemes in the architecture of Wroclaw: Façades form the Middle Ages to the Present*, Creativetime, Wroclaw-Krakow, 2014

---

[1] The paper is a result of the study conducted in the years 2010-15 on the original colour schemes of façades in Wroclaw from the Middle Ages to the present day. In regard to the original colour schemes form the first chronological phases results from research were published by the author in a monograph and a few articles and conference proceedings in the years 2013-15.

[2] For more details see the following publications: Line Bregnhoi, Helen Hughes, Jenni Lindbom, Tone Olstad and Edwin Verweij(eds), International Conference on *Architectural Paint Research in building Conservation*. Copenhagen 8 – 11 May 2005, London 2006; Baty Patrick, 'To Scrape or Not to Scrape?', *Traditional Paint News*, Vol. 1, No. 2, October 1996, pp. 9-15; Faulding Rachel, Thomas Sue (eds), *Architectural Paint Research: Sharing Information, Sharing Decisions,* Archetype Publications, 2014; Nilsen Lisa, Hinrichs Degerblad Kathrin (eds), *Standards in Architectural Paint Research*, Archetype Publications, 2014.

[3] Additional surveys were conducted in WKZ Wroclaw in February 2014 and in MKZ in September 2014. Conservators, architects and investors provided parts of documents directly.

A matter of life or death: identifying colour in the pictographs of the Lake of the Woods (northwest Ontario).

Alicia J. M. Colson
Royal Geographical Society, London, UK

The ability to distinguish between colours is often a matter of life and death. So whether or not the use of colour, or language used to describe the colours of the images created by the Algonquian speaking peoples of Lake of the Woods evolved in a structured manner might tell us much about their lives. Berlin and Kay [1] might be helpful here for they argue that the development of basic colour categories is based on the distribution of such categories across contemporary languages. However, perceptic Berlin and Kay's idea, employing it in relation to the pictographs is perilous. There is no clear chronological framework which might enable us to establish a chronology of the settlement patterns of the ethnic groups in this vast region over the previous millennium. To establish a sequence of the languages spoken is even more fraught with difficulties. So the first task is to establish such a framework, consulting a wide range of disciplines including history, anthropology, linguistics, and ethnohistory. Naturally enough researchers from these disciplines use the written record in very different ways to substantiate their conclusions[2]. The terms used to discuss language and its uses differ widely, depending on the discipline on which these observers drew. The task is made even more complicated by the uncertain linguistic designation of the Oji-Cree peoples who may have occupied the area in the recent past. Linguists have problems establishing the history of each language, especially given changes in dialects. The problems evident from the changing of groups' names might only be resolved by the systematic use of historical documents to gain a better understanding of the synonyms that existed. Dictionaries will have to be built for each source. Hartley's[3] study of the Lake Superior region which used the changes in place names recorded over time may prove a useful model. Continuous changes in the naming of the people who lived in this region renders it difficult, perhaps impossible to determine who lived in this region since 1500 let alone during the period covered by the archaeological record.

The colour used in visual imagery reflected the availability of materials. This makes it inherently difficult to chart a relationship between choice of colour and evolution. The Ojibwa, the indigenous people who live in the geographic region within which the Lake of the Woods exists, speak varieties of English and French today, with vocabulary drawn from highland scots and Quebecois. If they do speak their indigenous language they use a dialect of Ojibwa or Ojib-Cree. Ojibwa, Cree and Oji-Cree are challenging therefore anthropologists, archaeologists, and other practitioners interested in these images have tended to rely on indigenous informants. This reliance creates further difficulties since there are so many layers of interpretation separating the scholar from the 'source'. Establishing a clear chronological framework regarding the Ojibwa, who lived in this geographical region who are called the "Northern Ojibwa" seems an endeavour of doubtful utility.

A rigorous archaeological fieldwork conducted June – mid October 2001 indicates that pictographs are usually red, created from iron oxide mixed with isinglass. Black and white pictographs are rarity. Indeed, the pictographs created during the 1960s onwards were created using modern aerosol can paint in red, blue, white, green and grey. We may surmise that people used whatever was available. The colour used to create pictographs, beadwork and other images created by these same Algonquian speaking people was probably limited to the materials available either locally or obtained by traditional trades. At the same time the pictographs are only one of several forms of expression created by the Algonquian speaking peoples. Ethnographic and ethnohistoric evidence indicates that white beads were formerly used in the beadwork and quillwork from the region. They have been replaced by brightly coloured seed beads, obtained through the fur trade.

Observation, measurement and the use of data drawn from specific sites provides for a different view of the extent to which colour can be identified, whether or not it might be important, how its use might have changed over time and what this might indicate in terms of its value to those who created and utilized the pictographs.

References

[1] Berlin, B. & P. Kay (1999) *Basic Color Terms: Their Universality and Evolution* (The David Hume Series) The Center for the Study of Language and Information Publications; New edition

[2] Bishop, C. A. (1976) The Emergence of the Northern Ojibwa: Social and Economic Consequences. *American Ethnologist* 2: 39–54.

[3] Dawson, K. C. A. (1987) Northwestern Ontario and the Early Contact Period: the Northern Ojibwa from 1615-1715. *Canadian Journal of Anthropology* 17: 143-180.

[4] Greenburg, A. M. and J. Morrison (1982) Group Identities in the Boreal Forest: the Origin of the Northern Ojibwa. *Ethnohistory* 29 (20): 75-102.

[5] Schenk, T. (1994) Identifying the Ojibwa. In: *Actes du Vingt-Cinquième Congrès des Algonquinistes,* edited by W. Cowan, Carleton University, Ottawa, pp. 395-405.

[6] Valentine, L. P. (1995) *Severn Ojibwe Communicative Practices*. University of Toronto Press, Toronto, Buffalo and London.

[7] Hartley, A. H. (1980) The Expansion of the Ojibway and Place-names into the Lake Superior Region in the Seventeenth Century. *Names* 28 (1): 43-68.

Experiencing colour through painting

Shirine Osseiran
Independent Visual Artist, London, UK

The workshop facilitate experiencing colour through an individual experience by painting. After being offered to choose from different sets of colour palettes, the participant is invited to apply the paint freely on paper. The colour palettes include the 4 psychological colour group preferences along tones of colours. Colour choice and creativity are used as a therapeutic expereince by dealing directly with the energy of colours in a creative way. Choosing a set of colours can reflect a psychological type, current mood or need. Painting with colours involve looking, touching the colour directly or indirectly and then applying it to the surface.

Day #2 – Thursday 15th September

Session 4: Colour Cognition 1

Naming derived colour categories: orange, spectral purple and magenta

Thomas Bangert[1], Loredana Minini[2], Ebroul Izquierdo[1]
[1] Queen Mary University of London, England
[2] University of Oxford, England

It is often suggested that there are four primary colour categories and that all other colours of perception can be expressed as composites; produced by a mixture of two primaries located adjacent to each other on the visible spectrum. We have investigated this claim by allowing subjects to view monochromatic stimuli over the visible spectrum and asked them to name the colour perceived. All subjects (from a diverse range of cultural and ethnic backgrounds) readily identified red, green, blue and yellow as broad areas within the visible spectrum and they did so without being prompted. When asked to locate the 'best' example of each of these primaries they had no difficulty in doing this, and provided that the stimulus was bright enough (particularly with respect to yellow) the subjects were generally satisfied that the stimulus selected was an exemplar of the named colour. Once the primaries had been identified, intermediary colours were investigated. Monochromatic stimuli between blue and green were readily identified as "blue-green" (in varying proportions) and monochromatic stimuli between green and yellow were always described as a mixture of yellow and green. Yellow-green colours were rarely identified as named colours, but blue-green colours were generally identified by colloquial names (such as "aqua", "sea-green" and "sky-blue"). When a subject was presented with an optimal blue or green and the wavelength was then shifted to a just-noticeable difference (less than 1nm for subjects with good colour vision) between these primaries, all subjects reported perceiving a proportion of the adjacent primary (blue with a "hint of green" or green with a "touch of blue"). Subjects were very clear in reporting this perception of the adjacent primary; they reported that they can "see" small amounts of green or blue, or that the blue is "becoming" green or that some blue is being "added" to the green. In addition, they were able to estimate the proportion of the adjacent primary being added. This relationship, however, did not hold true for perceived colours between yellow and red, and for the colours on the periphery of the spectrum between red and blue. Stimuli between yellow and red were in all subjects identified as "orange". Subjects were in many cases intellectually aware that orange could be produced by mixing red and yellow but most subjects were very resistant to naming the adjacent primary when presented with the monochromatic stimulus. None of the subjects reported a proportion of the adjacent primary between yellow and red as they did with blue and green. Subjects reported "orange" as if it were a primary colour (such as reporting that the colour of the stimulus was red with a "bit of orange in it", or that it was yellow which was "becoming a bit orange").

On the periphery of the visible spectrum this was even more pronounced. In the range of 400-460nm most subjects reported the colour perceived as "purple". For a significant proportion of subjects (especially those with certain types of anomalous colour vision), the entire range was simply blue, and they failed to see any composite at all. Subjects with normal colour vision all reported variations on purple; some subjects reported an incomplete purple ("purple-ish") whereas others reported a mixture of purple and red at the extreme end of the spectrum (a purple "becoming a bit reddish").

In all cases where a subject reported perceiving purple, they reported it as if it were a primary, but there was considerable variation of the spectral position where the optimal purple was located. Priming subjects with prior knowledge did not affect how subjects reported perceiving the colour; almost all subjects who knew that purple could be produced by Red+Blue (from an advance questionnaire about the subject's knowledge of colour reproduction) when presented with a monochromatic purple stimulus failed to describe the colour as a mixture. Subjects were very resistant to identifying adjacent primaries (even when prompted), and were insistent that they were perceiving "pure purple". On the other extreme end of the visible spectrum (at about 650nm) about a quarter of subjects reported seeing a colour distinct from red, but in this case they were not only unable to name the colour they were perceiving but struggled to find suitable words to describe it; with two exceptions – one subject named the colour as "fuchsia" and one other subject described the colour as "pinkish".

Our empirical findings suggest that: [1] The convention of naming the lower range of the visible spectrum as 'violet' is in disagreement with our observations, as almost all of our subjects reported monochromatic stimuli in the region as "purple"; [2] Humans with good colour vision clearly perceive a perceptually distinct spectral (monochromatic) purple, which may be defined as the mid-point between the red and blue; [3] There is considerable variation between individuals in where the primaries and primary mid-points are located on the spectrum, particularly in the periphery of the visible spectrum; The perception of a mixture of the peripheral primaries at the extreme ends of the spectrum in some subjects suggests that the visible spectrum is represented by the human visual system as circular and that some humans with very good colour vision are able to perceive almost all the colours of this circle; Display technology for colour reproduction (or colour matching) should take into consideration individual variation of the spectral location of the primaries, particularly with primaries that are close to being monochromatic and primaries that are at the peripheries of the visible spectrum.

References

[1] Bornstein, M. H. (2006). Hue categorization and color naming: physics to sensation to perception. *Progress in Colour Studies*: Volume II, 35-68.

[2] MacAdam, D. (1985). *Color Measurement: theme and variations*. Springer.

[3] Wyszecki, G., & Stiles, W. (1967). *Color Science*. John Wiley.

Mapping and comparing the conceptual organisation of colour lexicons across 14 European languages: a points-of-view analysis of listing data

David Bimler [1], Mari Uusküla [2]
[1] Massey University, Palmerston North, New Zealand
[2] Tallinn University, Tallinn, Estonia

Applying the Method of Listing, a standard method for eliciting the most salient terms and concepts in a semantic domain [1-3], we asked speakers of 14 European languages to list colour terms in the order they came to mind. Speakers' lists can be conceived as a chain of associations from one term to the next, where the terms are nodes in a semantic network or map. Multidimensional scaling of the data represents the shared network for each language as a spatial model, locating the nodes so that consecutively-listed terms are adjacent [4].

Even if two terms in colour lexicons L1 and L2 are equivalent in their denotata, they may differ in their connotations, i.e. their associations with other terms. The present data came from eight Indo-European languages: English, Czech, Russian, Latvian, Lithuanian, Swedish, Spanish, Italian; five Uralic languages: Finnish, Hungarian, Estonian, Udmurt, Komi-Zyrian; and one Altaic language, Turkish (data were collected within a large-scale project run by author MU). Cross-language convergence of their models points to universal trends in the cognitive organisation of colour concepts – an organisation departing from the structure of perceptual similarity. These universal trends include distinctions between grades of salience, and between 'real colours' (prototypically chromatic) and 'borderline colours' such as grey or beige or silver, defined by their non-chromatic qualities or lack of saturation. However, this convergence coexists with slight differences among languages: for instance, some emphasise the chromatic aspect of their equivalents of 'pink' or 'brown', while in other languages these terms are dominated by their achromatic associations.

Here we quantify this convergence by defining an index of pairwise similarity between lists. The conceptual organisations of any two lexicons L1, L2 are <u>not</u> equivalent if the variance between speakers of L1 and L2 is larger than the within-language variance among them. If the latter is larger, one can speak of a common semantic network underlying both lexicons, simplifying the task of L1-L2 translation. We consider examples of both cases. This approach also allows the homogeneity of subjects within each language community to be tested, identifying subgroups of subjects who follow an aberrant strategy when accessing colour terms. No male-female differences could be discerned. When a pooled associational map is formed by combining lists across languages, a 'warm' / 'cool' distinction emerges, suggesting that this connotation is cross-cultural.

References

[1] Borgatti, S. (1999). "Elicitation Techniques for Cultural Domain Analysis". In *Ethnographer's Toolkit* (eds. J. Schensul, M. LeCompte), AltaMira, 115-151.

[2] Weller, S.C and Romney, A.K. (1988). *Systematic Data Collection,* Sage.

[3] Sutrop, U. (2001). List task and a cognitive salience index. *Field Methods*, *13*, 263-276.

[4] Bimler, D.L. and Uusküla, M. (2014). The map is the itinerary: Cognitive color space reconstructed from listing data for 11 European languages. *Perception, 48*, S68.

Spanish basic colour categories are 11 or 12, depends on the dialect

Julio Lillo[1], Lilia Prado-León[2], Fernando González[3], Leticia Álvaro[1], Humberto Moreira[1], Anna Melnikova[1]
[1]Universidad Complutense, Madrid, Spain
[2]Universidad de Guadalajara, Guadalajara, México
[3]Universidad de la República, Montevideo, Uruguay

Our research identified and compared BCTs (Basic Colour Terms) and BCCs (Basic Colour Categories) of three dialects of the Spanish language: The ones commonly used in, respectively, Spain (thereafter Castilian), Mexico (Mexican), and Uruguay (Uruguayan). Our data are relevant to integrate universalistic [1] and cultural [2] factors for explaining the BCCs' origin and evolution.

Our research included three tasks: (1) Elicited lists were used to identify Castilian, Mexican, and Uruguayan BCTs; (2) A naming task was used to establish equivalences among BCTs belonging to different dialects; (3) Boundaries delimitation was performed to map BCCs (colorimetric volume for each BCC in the CIELAB colour space. Chromatic area for each BCC in the *CIE u´v´* diagram).

Two hundred and two people from three different countries participated in the elicited lists task (naming, with closed eyes, as many different monolexemic colour terms as possible). For each dialect of the Spanish language the words appearing in more than 50% of the lists were considered BCTs. The main results provided by the elicited list task were: (1) Castilian and Mexican dialects had 11 BCTs but 12 BCTs appeared for the Uruguayan dialect; (2) 9 BCTs were identical in the three dialects (English equivalences showed in brackets). The 6 primary ones: *rojo* (red); *verde* (green); *azul* (blue); *amarillo* (yellow); *blanco* (white); *negro* (black). Three derived ones: *gris* (grey); *naranja* (orange) and *rosa* (pink). On the other hand, two derived Castilian BCTs only appeared in another dialect of the Spanish language: *Morado* (purple) and *marrón* (brown). Very important, the BCT "celeste" ("sky") only appeared in the Uruguayan. Finally, with minor differences among the dialects, the primary BCTs were more frequent than the derived ones (*gris*, *naranja*, *rosa, morado, marrón, celeste*).

Ninety participants (15 males and 15 females from each country) participated in the two tasks included in the second experiment. Both tasks were performed using colour transitions (gradual changes between the colours located in the transition extremes). The first task (extreme colours naming task) consisted in naming the colour of each transition extreme. The second task (boundary selection task) required selecting the colour located in the boundary between the categories corresponding to each transition extreme.

The main results of the naming task were: (1) the expected equivalences for 8 of the 9 BCTs appearing in the three dialects. That is, excluding blue, the same names were used for naming the same extremes colours across the three linguistic dialects. (2) There were colorimetric equivalences between the two following BCTs pairs: *Marrón*-café (brown); *Morado*-violeta (purple). For these pairs stimuli consistently named "A" by the dialect-1 were consistently named "B" by the dialect-2.

Figure 1 uses different colour lines for delimitating the chromatic areas corresponding to *rojo* (red, A) and *azul* (blue, 1.B) from the results provided by the boundary selection task. It can be seen that the chromatic area for red is very similar across the three dialects (Uruguayan, green line; Castilian, red line; Mexican, blue line). The similarity in the chromatic areas (*u´v´*values) also appeared in the colorimetric volumes (*L*, a*, b** values) for 10 Spanish BCCs: *rojo* (red); *verde* (green); *amarillo* (yellow); *blanco* (white); *negro* (black); *gris* (grey); *naranja* (orange); *rosa* (pink); *morado-violeta* (purple); *marrón-café* (brown).

Chromatic areas and colorimetric volumes showed that the colours named celeste in Uruguayan were a subset of those named blue in Castilian and Mexican (Figure 1.B). Comparing with the Uruguayan blues, the celeste area corresponded to smaller hue angles (hu´v´ values). In the colour space the *"celestes"* were higher in *L** and *b**, but lower in *a** . This colorimetric characterization of the blue-sky categories is similar to those found in other languages such as Russian, Greek, Turkish, or Italian, which also have 12 BCCs [3].

1.A Red chromatic area 1.B Blue chromatic area

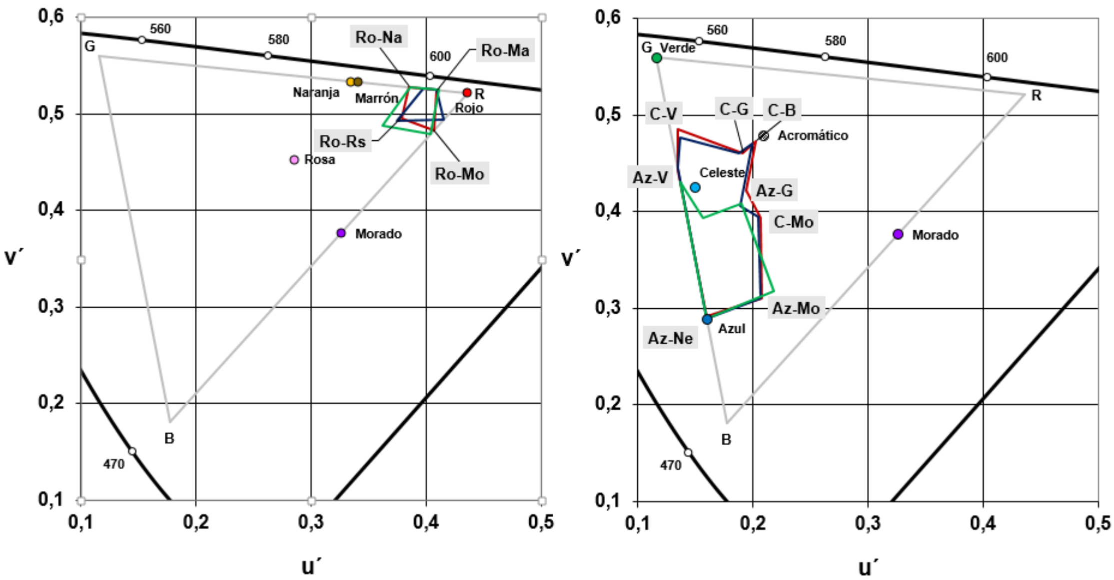

Figure 1. Chromatic areas for red (1.A) and blue (1.B). Mean measured boundaries are linked by coloured lines (Castilian, red; Mexican, blue; Uruguayan, green)

References

[1] Regier, T., Kay, P., & Cook, R. S. (2005). Focal colors are universal after all. *Proceedings of the National Academy of Sciences of the United States of America, 102*, 8386-8391.

[2] Roberson, D., Davidoff, J., Davies, I. R. L., & Shapiro, L. R. (2005). Color categories: Evidence for the cultural relativity hypothesis. *Cognitive Psychology, 50*, 378-411.

[3] Paggetti, G., Menegaz, G., & Paramei, G. V. (2016). Color naming in Italian language. *Color Research & Application*, 41, 402-415.

Diatopic variation in referential meaning of the 'Italian blues'

Galina V Paramei[1], Mauro D'Orsi[2], Gloria Menegaz[2]
[1] Liverpool Hope University, UK
[2] University of Verona, Italy

Recent psycholinguistic studies provide convincing evidence that Standard Italian has more than one basic colour term (BCT) for 'blue' (e.g. [2,3]). Across all studies there is consensus that *blu* is the counterpart of English 'dark blue'. The other deeply entrenched term, *azzurro*, was, however, found to convey 'light blue' for Verona speakers [3] compared to 'medium blue' for speakers in Alghero [4] and Florence [2]. Furthermore, in the latter studies a third term, *celeste* 'light blue', appeared to be cognitively salient too. In the present study we explored diatopic variation in the denotata of *blu*, *azzurro* and *celeste* by conducting a psycholinguistic experiment in Verona (Veneto region) and Alghero (Sardinia).

Participants were Italian monolinguals with normal colour vision: Verona N=15 (5 females); Alghero N=13 (7 females). Eight charts (Munsell Book of Color), encompassing the BLUE area of colour space, were employed: 5BG, 10BG, 2.5B, 5B, 7.5B, 10B, 2.5PB, 5PB. The charts were presented in fixed order (as above) in a viewing booth, under D65-metameric illumination; at the chart surface, luminance was 220 cd/m^2 (illuminance 1387 lux). For naming individual chips, an unconstrained colour naming method was used which allowed monolexemic and compound terms, use of modifiers or term suffixation. A given term could be used for naming more than one chip. This procedure was followed by indicating the 'best example' (focal colour) of *blu, azzurro* and *celeste*, for which all eight charts were presented concurrently.

In both Italian samples, the elicited 'blue' terms were of great variety (e.g. *azzurro, blu notte, turchese chiaro, celeste-lilla, bianco grigio, bluastro* etc.). The total number of different terms for the Veronese was 1109, compared to 500 for the Algherese. (The difference can be attributed to the experimenter effect: her/his encouragement in the instructions to diversify colour names). Also there was significant inter=individual variation in the number of the offered names, from 44—204 (Veronese) and 24—110 (Algherese). Notably, the Veronese used *celeste* infrequently and interchangeably with *azzurro*, with low agreement about its focus.

Table 1. CIELAB coordinates of centroids of the referential volumes (consensus threshold 40%) of the three 'Italian blues' for the Verona and Alghero participants.

Colour term	Verona sample (N=15)			Alghero sample (N=13)		
	*L**	*a**	*b**	*L**	*a**	*b**
Celeste	74.67	-8.03	-22.67	69.95	-7.68	-26.71
Azzurro	62.72	-8.29	-29.81	46.40	4.51	-50.84
Blu	33.38	-3.41	-30.64	28.75	-2.22	-30.61

For further analysis, Munsell coordinates of the stimuli (N=237) were re-notated in CIELAB space (http://www.cis.rit.edu/research/mcsl2/online/munsell.php). For the two samples, consensus in naming the BLUE area by *blu*, *azzurro* and *celeste* was explored. For each 'blue' term, a referential volume was estimated and fitted by a convex hull [1]. The convex hulls of referential volumes were visualized in CIELAB space. Taking into account the considerable diversity of colour terms from the unconstrained method, referential volumes were estimated as colours with naming consensus at the threshold 40% and 50%. Further, 'blue' category centroids were calculated by taking the weighted average of the coordinates of all chips named by the corresponding colour name. Finally, centroids of focal colour choices were estimated (Table 1).

The referential parameters confirmed that Italian *blu* is the cognate of English 'dark/navy blue' (Figure 1). The referential extent of *azzurro*, as anticipated, differed between speakers of the two regions revealing diatopic variation between these. Verona speakers use *azzurro* for denoting 'light-and-medium blue'. *Celeste* was named by them conspicuously less frequently, co-extending with the 'light *azzurro'* sub-range and functioning as *azzurro* hyponym. In comparison, for the Algherese, *azzurro* appears to denote 'medium blue'. It is complemented by *celeste*, denoting 'light blue' and having a referential volume markedly greater than that for Verona speakers. *Celeste* seems to be a contender for a third 'blue' BCT for speakers of this region although its focal colour is less stable than foci of *blu* or *azzurro*. The prominence of *celeste* is likely to result from Alghero speakers being exposed to Algherese Catalan dialect, with the influence of Catalan *celeste* 'light blue'.

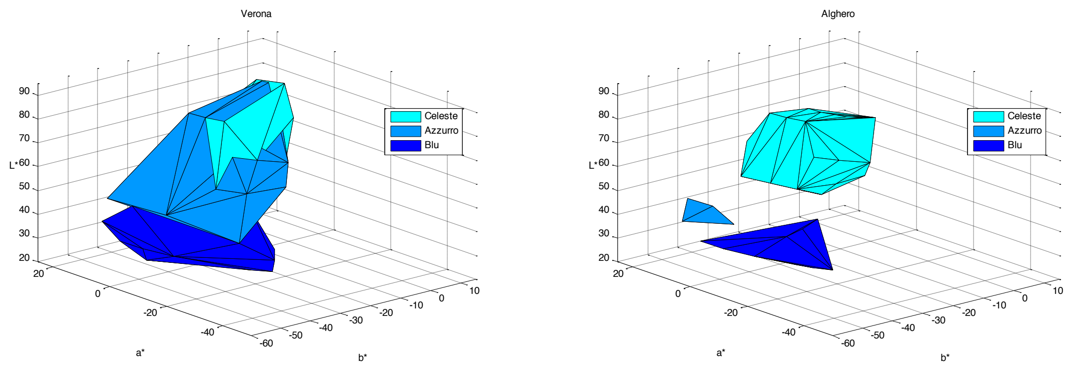

Figure 1. Referential volumes (in the CIELAB space) of Italian 'blue' terms *blu*, *azzurro* and *celeste* for the Verona sample (left) and Alghero sample (right); consensus threshold 40%

References

[1] Barber CB, Dobkin DP, Huhdanpaa H (1996). The quickhull algorithm for convex hulls. *ACM Trans Math Software, 22*, 469-483.
[2] Bimler D, Uusküla M (2014). "Clothed in triple blues": Sorting out the Italian blues. *J Opt Soc Am A, 31*, A332-A340.
[3] Paggetti G, Menegaz G, Paramei GV (2016). Color naming in Italian language. *Col Res Appl, 41*, 402-414.
[4] Paramei GV, D'Orsi M, Menegaz G. (2014). 'Italian blues': A challenge to the universal inventory of basic colour terms. *J Int Col Assoc, 13*, 27-35.

Keynote Lecture #3

Establishing a new database resource for cross-cultural color research: the Robert E. MacLaury color categorization (*ColCat*) digital archive

Kimberly A. Jameson
University of California at Irvine, Irvine, USA

The Mesoamerican Color Survey (MCS) collected color-naming and categorization data from approximately 900 speakers from 116 indigenous languages from regions in Mesoamerica. The MCS was developed, by Robert E. MacLaury, principle investigator of the survey, during the years 1978-1981, and analyses of these data were originally reported by MacLaury in the context of his Vantage Theory modeling approach.[1] The MCS is one of two large existing databases (the other being the World Color Survey, or WCS) that directly investigated, on a large scale, color naming and categorization across many linguistic societies. The MCS and WCS employ nearly identical standardized procedures for evaluating large numbers of color stimuli, languages and informants.

It is estimated that more than 100 indigenous languages are spoken in Mexico and Central America. Like most languages each MCS language has a color lexicon that partitions environmental color appearance stimuli according to a pattern that is specifically relevant to a given language's speakers. Moreover, every MCS color categorization system also shares characteristics with systems observed for other Mesoamerican languages and with those of languages elsewhere in the world. Recognizing the value in the MCS data, the interdisciplinary ColCat research group at UC Irvine sought to convert the paper copy of MacLaury's research archive into a public access digital database, similar to that developed for the widely-known WCS.[2] The entirety of MacLaury's MCS data, as well as that from his multinational data collection efforts, is included in the ColCat digital archive, representing a total of 212 surveys. MacLaury's additional 96 color categorization surveys are, in their own right, valuable for their diversity in that they include native speakers from a wide variety of languages such as Slavic languages, Hungarian, Salishan languages of the Pacific Northwest United States, Zulu and several South Africa/ Zimbabwe languages, Native American languages, Germanic languages, European languages, and Asian languages.

This talk presents research on preparing the archive's ~23,000 pages of paper copy into a public-access digital archive. In addition to manually transcribing a portion of the archive's handwritten data, we developed novel approaches for rapidly converting the archive to digital copy. Research results are presented for two complementary lines of investigation: the first involving approaches using Optical Character Recognition and machine learning to digitize the handwritten data, and a second approach using crowdsourced transcriptions of the data that were aggregated via an innovative variation of Cultural Consensus Theory analysis.[3, 4] A further aim of the project was to develop a platform to make the archive available to the scientific research and teaching community. Towards this aim we present The Robert E. MacLaury Color Categorization (ColCat) Digital Archive website, containing all of MacLaury's data as a public-access color categorization digital archive. The ColCat platform[5], including features of the Graphical User Interface developed for organizing the archive as a web-based resource, is presented.

References

[1] MacLaury, R. E., (1997). *Color and Cognition in Mesoamerica: Constructing Categories as Vantages.* University of Texas Press.

[2] Jameson, K. A., Benjamin, N. A., Chang, S., M., Deshpande, P. S., Gago, S., Harris, I. G., Jiao, Y., Tauber, S. (2015) "Mesoamerican Color Survey Digital Archive." Ronnier Luo (Ed.). *Encyclopedia of Color Science and Technology*, *Volume 2.* 909-921. Springer Science + Business Media New York. DOI: 10.1007/978-3-642-27851-8.

[3] Jameson, K. A., Deshpande, P. S., Tauber, S., Chang, S. M., Gago, S. (2016). Using individual differences to better determine normative responses from crowdsourced transcription tasks: An application to the R. E. MacLaury Color Categorization Archive. © 2016 *Society for Imaging Science and Technology, 115.1-9*. DOI: 10.2352/ISSN.2470-1173.2016.16HVEI-115.

[4] Deshpande, P. S., Tauber, S., Chang, S. M., Gago, S., Jameson, K. A. (in press). Digitizing a Large Corpus of Handwritten Documents Using Crowdsourcing and Cultural Consensus Theory. *International Journal of Internet Science.* To appear in 2016.

[5] Jameson, K. A., Gago, S., Deshpande, P.S., Benjamin, N.A., Chang, S.M., Tauber, S., Jiao, Y., Harris, I.G., Xiang, Z. Huynh, B.B., Ke, H., Lee, W.J., MacLaury, R.E. (2016). The Robert E. MacLaury Color Categorization (ColCat) Digital Archive. http://colcat.calit2.uci.edu/. *The California Institute for Telecommunications and Information Technology (Calit2)*. University of California, Irvine, USA.

Session 5: Development of Colour Perception and Cognition

Colour naming across the spectrum: developmental disorders and colour vision deficiencies

Matt Cranwell, Angela Owen, Gabriele Jordan, Anya Hurlbert
Institute of Neuroscience, Newcastle University, Newcastle upon Tyne, UK

Colour naming is highly variable between cultures, challenging the notion of an underlying universality in the linguistic carving of colour space into distinct categories. Yet colour naming is also highly variable between individuals within cultures [1,2], influenced by factors on several different levels, from the biological to the environmental. Here we quantify and compare the individual variability in colour naming due to biological factors affecting development and colour vision.

We start with the notion that naming colours serves the purpose of communication: an individual gives a name to a particular perception in order to enable him to communicate his perception to another individual. This notion underlies the "efficient-communication" explanation of cross-cultural variations in colour categories [3]. Analogously, we suggest that individuals who are impaired in social communication may exhibit less concordance with the colour language of their culture, due to lower communication drive or efficiency.

Colour naming behaviour is also dependent on the sensory ability to discriminate between colours. Individuals with colour vision deficiency (CVD) due to anomalies in the retinal photoreceptor complement (i.e. retinal "colour-blindness") are known generally to have atypical colour naming behaviour. Yet even within the subpopulation of CVD individuals, there is high variability in colour naming behaviour, depending not only on the type and severity of CVD, but also on other factors [4].

Here we compare the differences in colour naming behaviour – relative to the population norm between individuals who possess normal retinal trichromacy and normal chromatic discrimination ability but generally impaired communication ability, and those with anomalous retinal photoreceptor complements and atypical chromatic discrimination ability but typical communication ability. In particular, we compare colour naming by individuals diagnosed with Williams Syndrome (WS), characterised (in part) by unconventional social interactions, with that of their mental-age matched typically developed peers. We hypothesise that although both groups will show deviations from typical naming behaviour, the deviations will differ in pattern and extent.

Methods: Participant groups are as follows. Adults: normal trichromats (TD adult) (N=23; 14 females; mean 27 years); deuteranomalous (DA) (N=13 males; mean age 27 years); protanomalous (PA) (N=6; 1 female; mean age 35 years); deuteranopic (DD) (N=5 males; mean age 35 years); protanopic (DD) (N = 6 males; mean age 30 years). Children, all normal trichromats: typically developed (TD child) (N= 44; mean age 5.6 years); Williams Syndrome (WS child) (N = 23; mean age 12.8 years).

The task is untimed, free colour naming of samples in the MacBeth ColorChecker chart (either the 24-patch standard, for the child groups, or the 140-patch Digital ColorChecker SG, for the adult groups), under daylight illumination. (The task is part of a larger battery which includes anomaloscope diagnoses of CVD). We quantify the variability of individual colour naming by against normative data provided by the larger population, either from the same group or a reference group. The normative data has several components, including frequency of different types of colour term use (e.g. Basic Colour Terms (BCTs), Non-BCTs, and modified BCTs) and individual specific term use, for a specified set of colours. We further compute the concordance of an individual's colour name for a given sample in terms of the probability of that name being used for that sample by the defined population.

Specifically, to compute concordance: For a given group and set of colour samples, we compute the probability distribution of colour names (the name probability vector) for each sample by (1) collating all colour names used across all groups and samples, separated into main terms and modifiers; (2) constructing for each naming trial for each observer the colour name vector as the set of weights on each possible main term or modifier (weighting main terms more heavily than modifiers); and (3) for each sample, averaging these weights over the group. The individual concordance values are calculated as the closeness of the individual colour name vector to the name probability vector, using the Hellinger distance for similarity.

Results: Individual variability with respect to all measures is high in all groups. With respect to type of term used: in all groups, the most common term type used is BCT and the second most common term type is modified BCT. TD adults are more likely to use non-BCTs than any other group. With respect to both term use and concordance: Adult CVD groups show greater within-group variability than all other groups. With respect to concordance: the highest within-group concordance occurs for the TD child group; the WS child group show significantly reduced concordance in comparison with the TD child normative data; likewise, the colour vision deficient adult groups show significantly reduced concordance relative to the TD adult normative data, with the lowest group concordance occurring for the dichromat groups, relative to the TD adult norms (Figure 1a). Yet the pattern of concordance across colors differs for the two different types of atypical populations (Figure 1b). In particular, the WS child group have significantly lower concordance for desaturated and achromatic colors compared with chromatic colors, whereas the CVD adult groups have lowest concordance for the most chromatic colors (patches 7-18; See Figure 1b for example). Although concordance for the adult CVD groups improves when compared against their own group norm (vs the TD norm), the WS group worsens in concordance when compared against itself.

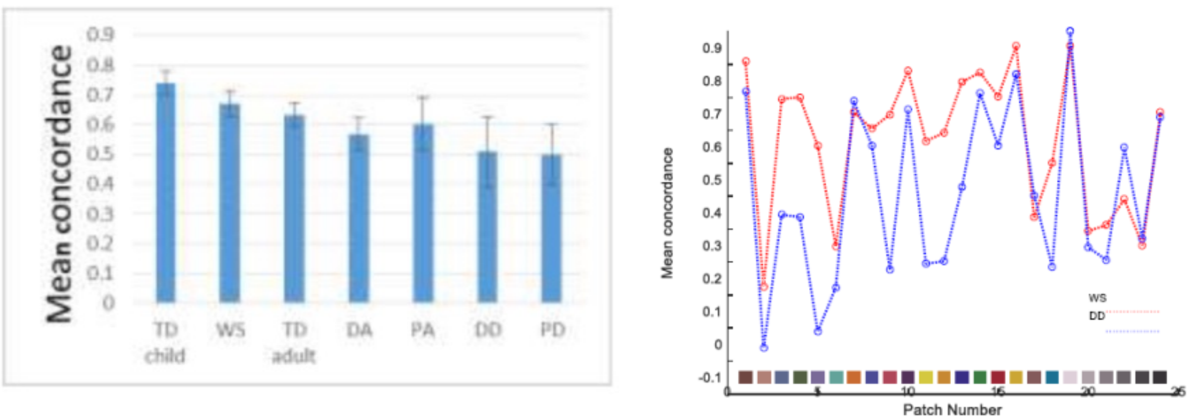

Figure 1. Left: mean concordance values, averaged over all 24 ColorChecker chart patches and all participants in each group, relative to the TD/NT norm for each group. Right: Mean concordance values for each patch, for the WS child group (red line) and deuteranopic adult group (blue line)

Conclusions: These results illustrate that individual variability in colour naming is affected differently by different biological factors. Although in the TD child group, verbal ability positively correlates with the use of both non-BCTs and modified BCTs, and negatively correlates with concordance, there are no such correlations for the WS child group, suggesting that the reduction in concordance with typical colour naming is related to color-specific categorisation or communication difficulties. Conversely, the reduction in concordance in the CVD adult group, relative to the TD norm, depends on the degree of perceptual deficit, and demonstrates a response to the need for colour communication.

References

[1] Webster, M. A., Webster, S.M., et al. (2002). *J. Opt. Soc. Am. A* 19(10): 1951-1962.

[2] Lindsey, D. T. & Brown, A. M. (2009). *Proc. Nat. Acad. Sci. Am.*, 106, 19785 -19790.

[3] Regier, T., Kemp C., & Kay,P. (2015). In B. MacWhinney & W. O'Grady (Eds.), *The handbook of language emergence* (pp. 237-263). Hoboken, NJ: Wiley-Blackwell.

[4] Roca-Vila J, Owen A, et al. (2011) , *J. Vis*, Vol.11, 386. doi:10.1167/11.11.386.

The maturity of colour constancy and colour term knowledge are positively related in early childhood

Marie Rogers[1], Christoph Witzel[2], Peter Rhodes[3], Anna Franklin[1]
[1] The Sussex Colour Group, School of Psychology, University of Sussex, Brighton, UK
[2] Laboratoire Psychologie de la Perception, Université Paris Descartes, Paris, France
[3] School of Design, University of Leeds, UK

Colour constancy is the ability of the human visual system to keep the appearance of the colour of surfaces the same despite changes in the illumination [1]. Several studies have argued for colour constancy in young infants based on findings from novelty preference methods and relatively simple stimulus and illuminant manipulations [e.g. 2, 3]. Basic mechanisms of colour constancy such as von Kries adaptation may be present in infancy [2]. However, colour constancy also involves the extraction of statistical regularities in the visual world [4], which is likely to depend on visual experience during development. Yet, it is unclear whether or how colour constancy matures during development. Therefore, it could be hypothesised that colour constancy strengthens as children obtain more experience with their visual environment.

In the current study we investigated colour constancy in 49 children during the period when colour terms are acquired 3 – 4 years [5]. Seven children were excluded for completing less than 50% of the trials, therefore data was analysed from 42 participants. We theorised that individual differences in colour constancy at this stage in development are related to the extent of colour term knowledge. This was theorised because colour term knowledge may help 'anchor' the representation of the surface colour during illuminant changes via either implicit or explicit top-down influence of colour naming [6, 7]. Additionally, immature colour constancy may make it challenging to learn colour terms by mapping them to coloured objects (e.g., yellow-banana), as the colour of objects would be less stable.

We measured colour constancy using a simultaneous matching task [8], where participants matched a colour target under one illuminant to one of four surfaces viewed under a different illuminant. One stimulus was a *light match* to the target in that it reflected light with the same sensory colour signal (LMS, XYZ) when under a different illumination. Another stimulus was the colour constant match in that it consisted of the same surface as the target. The other two stimuli were colorimetrically midway between the light match and the colour constancy match. The task was made into an age-appropriate game about finding matching coloured trousers for two bears (see [9] for a similar task). In order to control for general ability in colour discrimination, the matching task was also conducted with no difference in illumination between stimuli. Colour term knowledge was assessed by testing production and comprehension of the eight basic chromatic colour terms.

Each trial in the colour constancy task was scored out of three: a score of 3 represents the colour constancy match, and 0 the light match. A score of 2 represents selection of the midway stimulus colorimetrically closer to the colour constancy match, and 1 the stimulus closer to the light match. A colour constancy index for each participant was calculated by adding the scores on each trial and then calculating this as a percentage of the highest score possible for the trials attempted. The higher the score, the closer the child's choices were to the colour constancy match. Analyses revealed a positive correlation between colour constancy and colour term knowledge (r = .673, p < .001), even when taking into account the effect of age and discrimination (r = .706, p < .001).

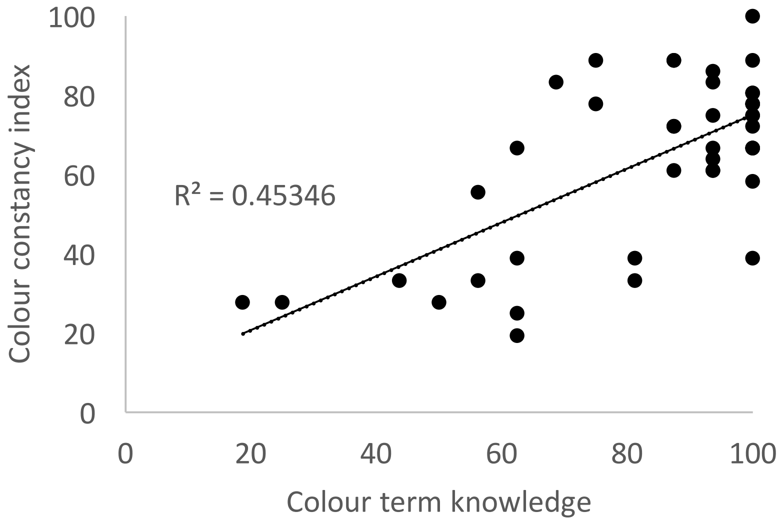

Figure 1. Relationship between colour constancy index and colour term knowledge (average % correct across comprehension and production of colour terms tasks, N = 42)

These findings suggest that children who have more mature colour constancy also tend to know more colour words and vice versa. These findings raise new questions about the origin of this relationship and development of colour constancy through children's interaction with their visual environment.

References

[1] Kraft, J. M., & Brainard, D. H. (1999). Mechanisms of color constancy under nearly natural viewing. *Proceedings of the National Academy of Sciences of the United States of America, 96*(1), 307–12.

[2] Dannemiller, J. L. (1989). A test of color constancy in 9- and 20-week-old human infants following simulated illuminant changes. *Developmental Psychology, 25*(2), 171–184.

[3] Yang, J., Kanazawa, S., Yamaguchi, M. K., & Kuriki, I. (2013). Investigation of color constancy in 4.5-month-old infants under a strict control of luminance contrast for individual participants. *Journal of Experimental Child Psychology, 115*(1), 126–36.

[4] Smithson, H. E. (2005). Sensory, computational and cognitive components of human colour constancy. *Phil. Trans. Royal Society B: Biological Sciences, 360*(1458), 1329–1346.

[5] Pitchford, N. J., & Mullen, K. T. (2005). The role of perception, language, and preference in the developmental acquisition of basic color terms. *Journal of Expt. Child Psychology, 90*(4), 275–302.

[6] Witzel, C., Maule, J., & Franklin, A. (2013). Focal colors as perceptual anchors of color categories. *Journal of Vision*, VSS2013 abstracts.

[7] Witzel, C., Sanchez-Walker, E., & Franklin, A. (2013). The development of categorical colour constancy. *Perception, 42*(ECVP Abstract Supplement), 19.

[8] Arend, L., & Reeves, A. (1986). Simultaneous color constancy. *Journal of the Optical Society of America. A, Optics and Image Science, 3*(10), 1743–51.

[9] Franklin, A., Clifford, A., Williamson, E., & Davies, I. (2005). Color term knowledge does not affect categorical perception of color in toddlers. *Journal of Expt. Child Psychology,* 90(2), 114–141.

What about colour attracts attention … and why?

Marc H. Bornstein, Clay Mash
Eunice Kennedy Shriver National Inst. of Child Health and Human Development, Bethesda, MD, USA

Two experiments set out, first, to examine a dimension along which infant preferential looking may be ordered and, second, to discern whether preferential looking might have identifiable neurophysiological substrates. The visual system codes chromatic saturation directly by increased neural excitation. We hypothesized that infant looking at saturated versus desaturated colours would be governed by the level of activity of neurons in the visual system selectively sensitive to those stimuli. Study 1 recorded infant looking at reds of two levels of chromatic saturation but the same brightness and hue: Infants paid reliably more attention to the more saturated of the pair. Study 2 evaluated infant and adult behaviour choice in relation to the activity of neural tissue. Infant data from both experiments are compatible with the hypothesis that the level of bioelectrical activity which is evoked by selected stimulation may serve as a neuronal substrate for the level of gross attention displayed by infants. These studies suggest that specific kinds of activity in the visual system are related to the degree of perceptual attention infants display to elemental stimulation.

Study 1

Fifteen 6-month-olds participated. None had a family history of colour-vision deficiency. Two 17.4° by 22.6° saturated and desaturated red fields with the same dominant wavelength of 630 nm were presented side by side on a monitor. Two versions of the display alternated the left-right arrangement of the saturated and desaturated fields. Each stimulus was presented twice over 4 10-s trials alternating the left-right position of the saturated region. An EyeTrac6 infant eye-tracking system recorded infants' fixations in relation to coordinates of the stimulus plane. For each trial, fixations were plotted directly on the stimulus images. Two raters coincided on 97% of trials. The durations of individual fixations were summed by saturation level, and preference scores (calculated by dividing the total duration of all fixations into the total for the saturated regions only) were compared to a chance response level (0.50). Infants preferentially fixated the more saturated field, $M = 0.61$, $SD = 0.16$, $t(13) = 2.70$, $p = .017$.

Study 2

Ten 6-month-olds and ten adults participated. None had a family history of colour-vision deficiency. Saturated and desaturated red fields with the same characteristics used in Study 1 were presented singly in random order on a monitor. Each trial consisted of a 300-ms baseline period, a 500-ms stimulus presentation, and an inter-trial interval (1800 to 2200 ms) during which the screen was black. Participants viewed 30 trials of each saturation level for a total of 60 trials. EEG was recorded with the EGI 128-channel EEG recording system. The EEG signal was referenced to the vertex, recorded with 20K amplification at a sampling rate 250 Hz, with bandpass filters set at 0.1-100 Hz, and with no more than 80 Ω impedance. Recordings were digitally filtered with a 40-Hz low-pass filter and segmented into saturated and desaturated trials using Netstation 4.1.2 Waveform Tools. A segmented trial consisted of 300 ms before stimulus presentation and 1300 ms after. Participants needed at least 10 artifact-free trials per saturation level to be included. An independent components analysis decomposed the signal into separate information sources. The channels selected for analysis were clustered around International 10-10 system sites P3, Pz, P4, P7, Oz, and P8. Signals from each channel were spectrally decomposed with a Morlet wavelet transform using EEGLAB running in Matlab v8.1. Event related spectral perturbation (ERSP) was calculated by subtracting the spectral power of the pre-stimulus baseline from the post-stimulus response. Time-frequency maps of ERSP responses were averaged over trials, participants, stimulus saturation, and channels for each cluster, and grand average maps examined. Infants' initial responses appeared around 80 ms within the beta and lower gamma bands (23-43 Hz), waning by 210 ms; adult responses appeared at 30 ms in a similar range of frequencies (13-53 Hz) extending through 235 ms. Early responses isolate sensory processes from post-perceptual ones. Recording site comparisons consisted of planned contrasts to examine response differences between the left and right hemispheres, between superior parietal and parietal-occipital regions, and between midline and lateral sites. A significant main effect of saturation level emerged, $F(1,18)=6.00$, $p=.025$, $\eta_p^2=.25$, with greater ERSP in response to saturated ($M=.59$, $SD=.62$) than desaturated stimuli ($M=.15$, $SD=.53$). No other effects were significant.

Conclusions

Infants prefer to look at saturated to desaturated red, and saturated as opposed to desaturated red evokes greater excitation (spectral power in the beta and gamma frequency bands) of neural tissue at superior parietal sites in the infant (and adult) brain.

Session 6: Colour Cognition 2

The dynamics of color preferences: evidence from seasonal variations

Karen B. Schloss[1,2], Isobel A. Heck[1,3]
[1] Department of Cognitive, Linguistic, and Psychological Sciences, Brown University, Providence, USA
[2] Department of Psychology and Wisconsin Institute for Discovery, University of Wisconsin, Madison, USA
[2] Department of Human Development, Cornell University, Ithaca, USA

Central questions in color cognition concern how and why colors influence the way people think, feel, and behave. Although much of this work has focused on color preferences, researchers are only beginning to understand why color preferences exist, how they are formed, and why they change with experience. Palmer and Schloss [1] proposed the Ecological Valence Theory (EVT), which posits that preference for a given color is determined by the combined valence (liking/disliking) of all objects and entities associated with that color. The EVT implies that preference for a color should change with changes in preferences for objects associated with that color and with changes in activation of color-associated objects in the observer's mind. For example, reminding observers of relatively liked (disliked) color-associated objects should increase (decrease) preference for that color [2-4].

Recently, Schloss et al. (in press) tested whether seasonal variations in color preferences could be explained by the EVT. They measured the same participants' color preferences in fall, winter, spring, and summer in the Northeastern U.S., where there are drastic seasonal changes in weather and environmental colors. Afterward, the same participants rated how strongly the colors were associated with each season. The primary differences were between fall and the other seasons. Participants liked dark-warm colors that were strongly associated with fall more in fall than during the other seasons, and they liked light-warm, light-cool, and dark-cool colors less during fall. These seasonal changes in color preferences could be predicted, in part, from seasonal changes in the activation of seasonal objects that were associated with the colors (e.g., pumpkins being more associated with fall than with other seasons).

These results open multiple questions. First, were the changes in color preference only evident for fall relative to the other seasons because of an order effect, given that fall was tested first? Second, can a purely exposure-based account explain the changes, without considering preferences for ecological objects? The classic mere exposure account states that increased exposure leads to increased liking [5], so it is possible that increased exposure to dark-warm colors during fall from autumnal foliage causes an increase in preference for those colors during fall.

We addressed these questions by conducting a within-subject (*n*=29), longitudinal study during fall. Participants completed 9 testing sessions over 11 weeks, starting in late September when the leaves were still lush green and ending in early December when the trees were bare. During each session, participants rated their preference for each of the Berkeley Color Project 37 (BCP-37) colors, as in [4]. We documented changes in the environment by taking photographs every week during the study. We also collected autumn leaves and determined which of the BCP-37 colors best corresponded to the leaf colors (henceforth "autumn leaf colors"). At the end, participants rated how much they liked each object/entity/event (henceforth "objects") that the participants in [4] associated with fall.

We first examined average preferences for autumn leaf colors vs. non-leaf colors as a function of testing session. If Schloss et al.'s [4] results had been due to an order effect, then preference for autumn leaf colors should peak in an early testing session, even though the leaves had not yet turned. However, if the changes were due to activation of seasonal objects, preferences for autumn leaf colors would peak in the middle of the season when the leaves were most multicolored and when fall-associated objects (e.g., pumpkins and hayrides) were especially active. Supporting the latter, average preferences for autumn leaf colors followed a significant quadratic pattern, peaking when the leaves were most autumnal (session 6.6), and declining by the last session. There was no corresponding pattern for non-leaf colors.

We next compared mere exposure and EVT accounts for these changes. If mere exposure were the sole explanation, then all participants who have the same environmental experiences should show the color preferences. However, the EVT predicts that the degree to which an individual's preference for autumn leaf colors increases in fall (Δp) should depend on how much she/he likes objects associated with fall. Across individuals, Δp was significantly correlated with preferences for fall-associated objects (r=.48, p<.05): Participants who had a greater preference for fall-associated objects showed a greater increase in preferences for autumn leaf colors over testing sessions. These results challenge a mere exposure account and demonstrate that seasonal changes in color preferences can be explained, in part, by the EVT. The results provide new evidence for how color preferences are dynamic, changing according to individuals' experiences within their environment.

References

[1] Palmer, S. E., & Schloss, K. B. (2010). An ecological valence theory of human color preference. *Proceedings of the National Academy of Sciences, 107*(19), 8877-8882.

[2] Strauss, E. D., Schloss, K. B., & Palmer, S. E. (2013). Color preferences change after experience with liked/disliked colored objects *Psychonomic Bulletin & Review, 20*(5), 935-943.

[3] Schloss, K. B., & Palmer, S. E. (2014). The politics of color: Preference for Republican-red vs. Democratic-blue. *Psychonomic Bulletin & Review, 21*(6), 1481-1488.

[4] Schloss, K. B., Nelson, R., Parker, L., Heck, I. A., & Palmer, S. E. (in press). Seasonal variations in color preference. *Cognitive Science*.

[5] Zajonc, R. B. (1968). Attitudinal effects of mere exposure. *Journal of Personality and Social Psychology, 9*, 1-27.

Ad hoc color concept mapping and interpreting information visualizations

Yun-hsuan Lai[1], Leslie Welch[1], Karen B. Schloss[1,2]
[1] Dept of Cognitive, Linguistic, and Psychological Sciences, Brown University, Providence, USA
[2] Dept of Psychology and Wisconsin Institute for Discovery, University of Wisconsin, Madison, USA

Colors represent concepts in information visualizations. For example, colors distinguish different categories in graphs and signs, and they display different quantities in spectrograms and weather maps. Does the specific mapping between colors and concepts influence observers' ability to interpret the depicted information? Evidence suggested that when bar graphs depict data about objects that have characteristic colors (e.g., fruit) observers are faster at interpreting the data when the bar colors correspond to the colors of the objects (e.g., banana-yellow, not banana-blue) [1]. Does color-concept mapping matter for visualizations that present data about abstract concepts or objects that do not have observable characteristic colors (e.g., *virus M*; *virus Q*)?

We addressed the problem by following Perceptual-Cognitive Mapping (PCM) approach [2] to understand how perceptual features map onto abstract concepts. In this framework, there is an *internal mapping* between perceptual features (e.g., colors, shapes, textures) and concepts in the observer's mind, and there is a *stimulus mapping* between perceptual features and concepts in visualization (e.g., mappings specified by legends/labels). PCM predicts that observers are faster at interpreting visualizations when the internal mapping matches the stimulus mapping. Therefore, it is possible to diagnose the nature of internal mappings by identifying the stimulus mappings that facilitate the fastest response times (RTs).

The present study investigated whether internal mappings can be learned from exposure to new color-concept stimulus mappings (e.g. fictitious lecture slides), and explored the nature of the learned mappings. We use the term *ad hoc mappings* to refer to learned internal mappings that are adopted on-the-fly for the purpose of interpreting a specific series of information visualizations. The paradigm for Experiments 1-2 contained a series of 3-trial-blocks (one bar graph per trial), including two learning trials followed by a test trial. In each trial, participants answered a two-alternative forced choice (2AFC) question about the graph. The graphs displayed fictitious data in a 2x2 design with an interaction between two factors. One factor was depicted on the x-axis (*x-axis factor*) and the other was depicted in separate bar colors specified in a legend (*legend factor*). In the two learning trials within each block, the color–concept stimulus mappings for the legend factor were the same (e.g., c_1-red; c_2-blue), but the x-axis concepts varied. In the test trial, the stimulus mapping was either the same as, or different from, that in the learning trials. We systematically varied the way the stimulus mapping in the test trials differed from the learning trials in both experiments to test whether participants formed ad hoc mappings (Experiment 1) and to begin to understand how those mappings are represented in the mind (Experiment 2).

In Experiment 1, we tested whether participants formed ad hoc mappings during the learning trials by comparing RTs for test trials in which the stimulus mappings were the same or different. There were 16 3-trial-blocks to accommodate the following design for the test trial: 2 bar color schemes [same/different] x 2 legend concepts [same/different] x 4 replications. RTs were faster when test trial mappings matched learning trials (same-color/same-concept) than when they mismatched (same-color/different-concept, $p<.05$; different-color/same-concept, $p<.05$) or were new (different-color/different-concept, $p<.05$) (color x concept interaction $p<.05$). Therefore, participants formed ad hoc mappings, such that violating these newly learned internal mappings slowed performance.

In Experiment 2, we investigated whether ad hoc mappings depend on exact surface matches between colors in learning and test trials, or if they can code deeper relational information. For example, can observers form ad hoc mappings based on relative lightnesses, even if the hues differ between learning and test trials? We addressed this question by changing the learning trials so that legend concepts were represented by two colors of the same hue but different lightnesses (e.g. c_1-dark blue; c_2-light blue). In the test trials there were four possible mapping conditions from the combinations of hue (same/different) x lightness relation (same/different). RTs were faster when the lightness relation was preserved ($p<.01$), regardless of whether the hues were the same or different (no interaction; $p > .05$). Therefore, ad hoc mappings encode relational information without relying on surface matches.

This study provides new evidence that novel, arbitrary mapping between colors and concepts can be learned with minimal exposure (ad hoc mappings). Therefore, prior experience with color-concept mappings in a series of data visualizations (e.g., in lectures, textbooks, and journal articles) influences the interpretation of subsequent visualizations. The results not only reveal how internal mappings can be formed, but they also provide insight into how color design can facilitate visual communication.

References

[1] Lin, S., Fortuna, J., Kulkarni, C., Stone, M., & Heer, J. (2013). Selecting Semantically-Resonant Colors for Data Visualization. *Computer Graphics Forum*, *Vol. 32*, pp. 401-410.

[2] Schloss, K. B., Gramazio, C., Silverman, A., & Lai, Y. H. (in preparation). Perceptual-Cognitive Mapping and the interpretation of colormap data visualizations.

Colour choices for induced joy, relaxation, fear, and sadness

Betty Althaus, Christine Mohr, Nele Dael
Institute of Psychology, University of Lausanne, Switzerland

In daily life, we use colours to express how we feel, with statements like "to feel blue", "to be green with envy" or "to see red". All those common expressions lead us to think that we all imagine the same colour when feeling an emotion. However, an association between certain emotions and colours might not be the same for everyone. In this study, we investigated in wich way the three colour parameters (hue, chroma, lightness) link with colour choices subsequent to the induction of one of four induced emotions (joy, fear, sadness and relaxation).

We used a mixed-procedure of musical listening combined with reading of vignettes found to induce the target emotion [1]. Immediately after inducing one of the four emotions, participants (n = 96) used a colour-picker to choose the colour they thought best represents the emotion they felt.

Chi-squared analyses revealed that yellow was chosen more than the other hues for the induced emotion of joy, and yellow-green for the induced emotion of relaxation rather than the other emotions. Fear and sadness had no dominated hue but both (negative emotions) were more often blue. Across hues, colours selected for joy and relaxation (positive valence) were significantly brighter and more chromatic than colours selected for fear and sadness (negative valence). Arousal had an effect on chroma but not on lightness: high arousal emotions were saturated than low arousal emotions.

The current findings indicate that all three colour parameters, i.e. lightness, chroma and hue, contribute to colour choices subsequent to an emotion induction procedure. These findings support previous research on colour-emotion associations especially about a valence-based association with brightness /saturation and an arousal-based association with saturation.

Reference

[1] Mayer, J., Allen, J., & Beauregard, K. (1995). Mood inductions for four specific moods: A procedure employing guided imagery vignette with music. *Journal of Mental Imagery, 19*(1&2), 133-150.

Session 7: Colour Imaging

A spectral and colorimetric artist paint database

Roy S. Berns
Rochester Institute of Technology. Rochester, New York, United States

Spectral (e.g., SOCS [1], Leeds [2]) and colorimetric (e.g., Pointer [3]) databases are commonly compilations of many materials. In this research, an Artist Paint Database was produced specifically for cultural heritage imaging and museum lighting, among others.

Nineteen Golden Artist Colors Heavy Body acrylic dispersion paints were used. Samples were prepared of each of the paints directly from the tube (masstone), mixed with white (tint), and mixed with white and black. They were applied to a Laneta coated paper substrate using a drawdown bar with sufficient thickness to achieve opacity. Samples were measured using an integrating sphere spectrophotometer, specular included.

The opaque form of Kubelka-Munk (KM) turbid media theory was used to produce mixtures of multiple paints computationally. The masstone-tint [4] or regression [5] methods were used to estimate each of the paint's absorption and scattering properties as a function of wavelength. The Saunderson equations were used to compensate for refractive index discontinuities at the paint-air interface and to predict the application of a glossy varnish layer.[6] Modeling accuracy was verified for pyrrole orange mixed with white and with black, and with a glossy varnish applied.

Using the KM model, spectra were estimated for each of the chromatic paints mixed with white and with black at varying ratios, followed by applying a glossy varnish. For some regions of color space, there was insufficient sampling and hue-adjacent paints were intermixed. CIELAB coordinates of the 770 spectra forming the database were calculated for Illuminant D50 and the 1931 standard observer and plotted in Figure 1, revealing the colorimetric sampling scheme.

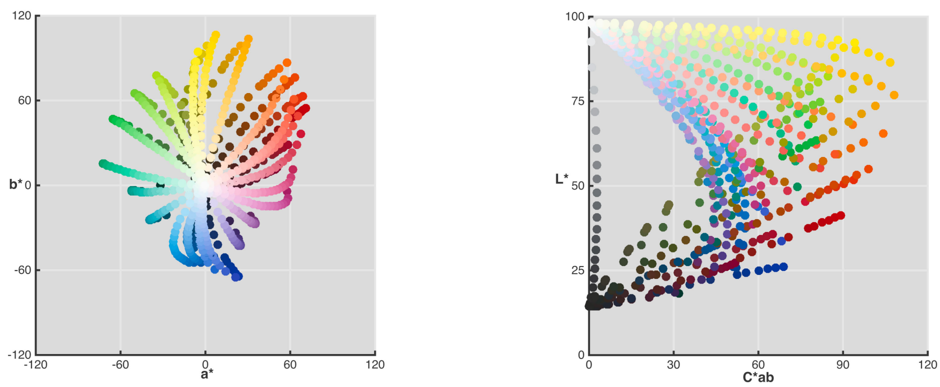

Figure 1. CIELAB coordinates of the artist material spectral database.

Several applications will be described. One will evaluate encoding errors caused by a rendering-gamut having too small of a volume. (This was one reason ProPhoto RGB was created.) A second application is museum lighting where color rendering (fidelity), color preference, and color inconstancy can be evaluated. A third application is using the database for spectral reconstruction from multispectral imaging systems [8].

This research was supported by a grant from the Andrew W. Mellon Foundation.

The Artist Paint Database can be downloaded at www.rit.edu/cos/colorscience/mellon

References

[1] International Organization for Standardization. 2003. “Graphic technology–standard object colour spectra database for colour reproduction evaluation (SOCS)”, ISO Norm 16066.

[2] Li, C., M. R. Luo, M. Pointer, and P. Green. 2014. “Comparison of real colour gamuts using a new reflectance database”, Color Research Application 39(5):442–451.

[3] Pointer, M. R. 1980. "The gamut of real surface colours", Color Research Application 5:145-155.

[4] Berns, R. S., and M. Mohammadi. 2007. "Evaluating single- and two-constant Kubelka-Munk turbid media theory for instrumental-based inpainting", Studies in Conservation 52(4):299-314.

[5] Walowit E., C. J. McCarthy, and R. S. Berns. 1987. "An algorithm for the optimization of Kubelka-Munk absorption and scattering coefficients”, Color Research Application 12:340-343.

[6] Abed, F. M., R. S. Berns, and K. Masaoka. 2013. "Geometry-Independent Target-Based Camera Colorimetric Characterization", J. Imaging Science and Technology 57:50503-1-50503-15(15).

[7] David, A., P. T. Fini, K. W. Houser, Y. Ohno, M. P. Royer, K. A. G. Smet, M. Wei, and L. Whitehead. 2015. "Development of the IES Method for Evaluating the Color Rendition of Light Sources", Optics Express 23:15888–15906.

[8] Ribes, A. and F. Schmitt. 2008. “Linear inverse problems in imaging”, IEEE Signal Processing Magazine, July:84-99.

Exhibiting the Antarctic: photography, temporality and colour in landscapes of early 1900s polar expeditions

Elizabeth Watkins
University of Leeds, UK

The late 1800s and first decades of the twentieth century saw an escalation in the use of photographic technologies - lantern slides, still images, aerial photography and film – to record the work of geographical expeditions and to convey the narratives of exploration to a public audience.[1] Polar expeditions of the Heroic Age of Polar Exploration were contiguous with the earliest days of cinema. An analysis of the technologies - watercolours, written accounts, cinematography, photography, annotated sketches – finds that each medium is marked by its technical possibilities and limits. These materials and technologies are entwined with and yet do not determine images and narratives of the Antarctic interior as a region hitherto unmapped beyond its peripheral shifting shoreline and the abstract points of longitude and latitude. The role of photographic media in mapping and mythologisation of polar landscapes has been addressed as a region characterised by its sparse representation – a white space – read as 'atemporal'.[2] However, colour, as a mode of study which was integral to the identification of wildlife and recording features of the landscape (minerals) and meteorological effects signals the temporality of the environment and its representation. The chromatic effects of light refracted by ice – paraselena, corona, Aurora Australis and the refraction of light from ice into myriad colours that occurred at the sunrise and sunset of long polar nights – were not directly registered and visualised through any single technology, but can be traced through a configuration of expedition records.

The significance of colour can be discerned in the sketches made by expedition member Dr Edward A. Wilson on the Southern Sledge Journey to the Pole. These 'memory notes' reveal the privileging of tonal values over hue, a practice which is in keeping with his studies of Ruskin's *The Elements of Drawing*. The emphasis on tone and form in his pencil and ink sketches is accompanied by elaborate notes on colour: from the refraction of light reflected by ice to the halo and ghosting effects that encircle the sun. Plans to exhibit watercolours alongside the 'camera artist' Herbert G. Ponting's photographs signal the difficulties that were encountered in 'securing good colour records' of the Antarctic.[3] Thus the history of colour as an amalgam of theories and practices can be tracked through the intermedial processes of recording and exhibiting the Antarctic landscape.[4]

In turn, the 'vivid descriptions' offered by Ponting on his return to London were attentive to sound, silence, odour, colour and movement as senses and perceptions that were not directly recorded by his photography.[5] The colouring of lantern slides and the cinematographic records which Ponting combined in the exhibition of his work is entwined with the formation of a narrative to evoke those sensory aspects of perception that were not directly registered by any single record. The practices that can be tracked through the exhibition of the visual records of the expedition underpin the combination of still-images, colour instructions, paintings, sketches, and inter-titles that are woven into narrative form of *The Great White Silence* (Ponting 1924). Colour, ephemeral in its manifestation and beset by delay between notation and its evocation in visual narratives of the expeditions, traces a discourse of temporality and the interactions of body and landscape.

References

[1] Ryan, J. (1997). *Picturing Empire: Photography and the Visualization of the British Empire*. Reaktion Books. p.193. Dixon, R. (2007). What was Travel Writing? Frank Hurley and the Media Contexts of Early Twentieth-Century Australian Travel Writing. *Studies in Travel Writing*, 11. pp.59-81

[2] Yusoff, K. (2010). Configuring the Antarctic. eds. Naylor, S. and Ryan, J. *New Spaces of Exploration*. I. B. Tauris;

[3] Ponting, H. G. (1910). *Daily Mail*, 31 May. *The Times*, (Saturday 28th May 1910), p.8.

[4] Gage, J. (1993) *Colour and Culture, Practice and Meaning from Antiquity to Abstraction*, Thames and Hudson.

[5] Scott, R. F. ([1910-12] 2006) *Journals, Captain Scott's Last Expedition*. ed. M. Jones. Oxford University Press. Ponting, H. G. ([1921] 2000) *The Great White South*. New York: Cooper Square.

Poster Session #2

Overestimation of colour brightness on clothing in positive emotion expressions

Nele Dael, Betty Althaus, Christine Mohr
Institute of Psychology, University of Lausanne, Switzerland

Systematic mappings have been found between colour components and affective dimensions [e.g., 1]; brighter colours are particularly associated with more positive affect. This link is supposed to drive behavioral responses congruent with the affective meaning associated to the colour. We here investigated whether affectively salient information surrounding a colour impacts how we judge to have perceived the brightness of that colour. In two experiments, participants mind-matched the brightness level of previously seen upper-body clothing of two actors (male and female) dynamically expressing four emotions. In both experiments, the estimation of brightness was higher for positive emotional expressions (elated joy, relief) than negative ones (hot anger, sadness). Moreover, these effects occurred independent of the hue of the clothing (grey, red, or yellow). Finally, these effects occurred for the male actor only (in both experiments). This study shows that emotional expression biased colour reproduction in line with the valence-brightness association. The current findings indicate that emotionally salient information but also other information such as person variables affects basic colour cognition, beyond mere perception.

Figure 1. Video stills illustrating bodily emotion expressed with upper body clothing digitally coloured

[1] Valdez, P., & Mehrabian, A. (1994). Effects of color on emotions. *Journal of Experimental Psychology: General*, *123*(4), 394–409

What colours do people see in fragmented vs whole versions of #The Dress?

Domicele Jonauskaite[1], Christine Mohr[1], Laetitia Chèvre[1], C. Alejandro Parraga [2], Nele Dael[1]
[1]Institute of Psychology, University of Lausanne, Lausanne, Switzerland
[2] Comp. Vis. Centre, Universitat Autònoma de Barcelona, Barcelona, Spain

In March 2015, a new visual colour illusion emerged on the Internet – the Dress. Although blue and black, some people see the dress as white and gold and others as blue and black. This illusion is unlike any other known colour illusion because not all people have the same perception [1]. It is unknown, however, whether the Dress must be shown as a whole, as it appeared on the Internet, to evoke the illusionary perception, or whether seeing parts already evokes different perceptions. Here, we asked 57 participants (10 males) to use a colour picker to match colours they saw on the screen as well as report their subjective colour perception. We had three context conditions: (a) the original Dress picture as it circulated the Internet; (b) small squares cut out of various parts of the Dress and (c) vertical strips cut out of the Dress. When participants saw the original Dress picture, we also asked them which colours they were seeing.

Our population consisted of three viewer types: 22.81 % saw blue and black (BB), 29.82 % saw white and gold (WG) and 42.11 % saw blue and brown (BBr). The hue of the selected colours did not differ across context conditions: All three viewer types chose blue-cyan hues for lighter parts of the dress (reported as white/blue) and orange-yellow hues for darker parts of the dress (reported as gold/black/brown, see Fig 1.). The subjective differences between viewer types were best accounted for by variations in saturation and lightness: BB viewers reproduced darker (as compared to WG and BBr viewers) and less saturated colours (as compared to WG viewers) when the original Dress was presented, but not when squares or strips were presented.

These results show that the Dress effect emerges when all aspects of the picture are integrated (contextualized information), rather than from inter-individual differences in objective perception of fragmented information, making this one of the crucial properties behind the effect. The reason behind this may have to do with disrupting prior information (familiarity with the fabric or the situation) or indeed expectations about the chromatic properties of the illumination itself.

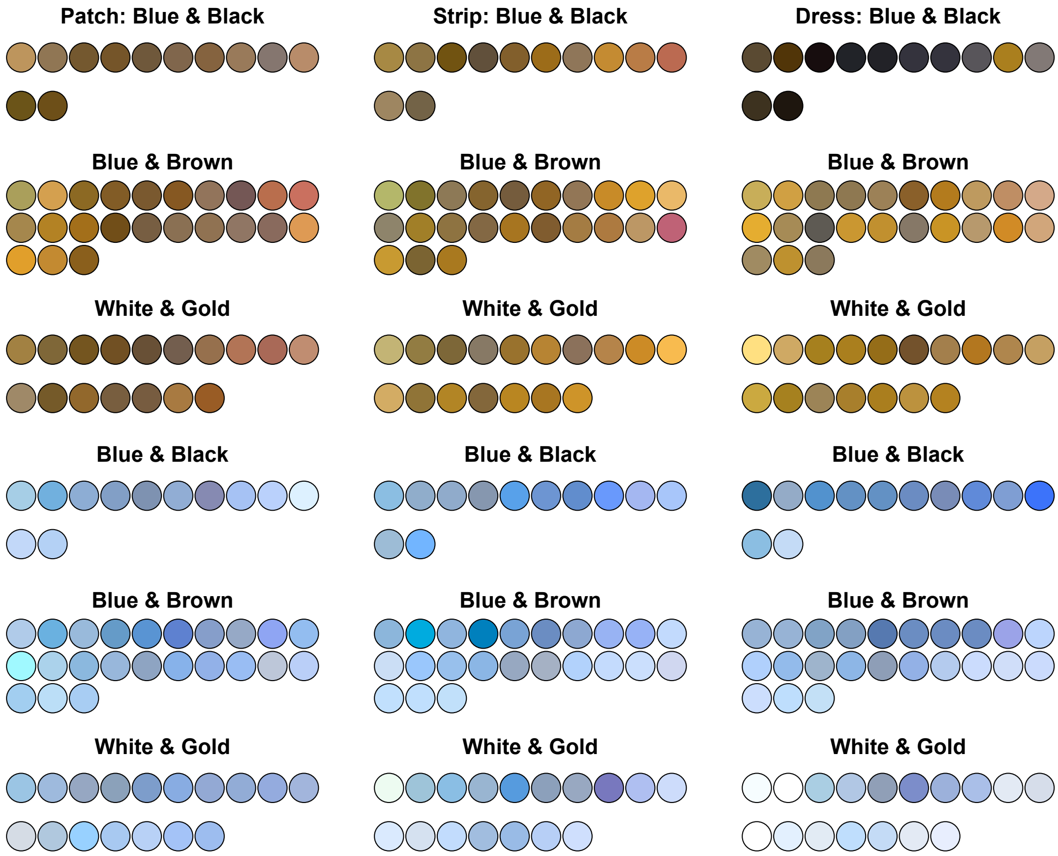

Figure 1. Colour selections for patches, strips and the full dress by blue & black, blue & brown, and white & gold viewers.

[1] Brainard, D. H. & Hurlbert, A. C. (2015). Colour Vision: Understanding #TheDress. *Current Biology*, *25*(13), R551–R554. http://doi.org/10.1016/j.cub.2015.05.020

Circular yellow, blue square: results of a cross-cultural investigation of Kandinsky's colour-form combination theory

Sebastian Walter
Deutsches Archaeologisches Institut, Berlin, Germany

In his 1912 published book "Über das Geistige in der Kunst" (Concerning the Spiritual in Art) the Russian painter and pioneer of non-representational art Wassily Kandinsky presented his theory of aesthetically optimal colour-form combinations: Different forms and colours own different characters or psychological effects.

Therefore there are aesthetically better fitting and less fitting colour-form combinations [1]. The central concept of Kandinsky's colour-form relationships is that of temperature [2]. He extends the since Goethe's "Farbenlehre" known association of temperature sensations with colours to forms, assigning certain temperatures also to certain forms. On the basis of colour temperatures and form temperatures Kandinsky develops a system of colour-form correspondences, described in more detail in "Punkt und Linie zu Fläche" (Point and Line to Plane) [3]. Following this concept, the elementary colours yellow, red and blue correspond to the elementary forms triangle, square and circle (compare figure 1).

To answer the question whether this postulated universal law of psychological relationship between form and colour exists, an inquiry was carried out at the German Bauhaus according to Hirschfeld-Mack [4], most likely in 1923. The result was "an overwhelming majority for yellow in the triangle, red in the square and blue in the circle". But the results passed on by Hirschfeld-Mack couldn't be verified by later investigations [5,6]. It was proposed that preferences for certain colour-form combinations are due to world knowledge and cultural influences [6].

The present study re-investigated the postulated preferences for certain elementary colour-form combinations, this time following a cross-cultural approach: German an ni-Vanuatu students were tested by means of a questionnaire. Vanuatu (former New Hebrides) is an island state in the South Pacific, with a Melanesian culture and low urbanization.

The questionnaire consisted of two main parts. In the first part the subjects should indicate which of the colours blue, green, yellow and red appeared to them to fit best with the forms square, triangle and circle, respectively. Each form was displayed in all four colours on a single page of the questionnaire. In the second part the subjects should indicate the best fitting form for each colour. All three forms were displayed together in one of the four colours at a time. In the first part of the investigation 171 German students (average age 20) were tested, in the second part 61 ni-Vanuatu students (average age 22).

For German students, both, the choice of the preferred colour for the square and that for the triangle, performed significant results: With the square, observers showed a clear preference for blue (about 50 %). The results for the triangle established sex specific differences: Women preferred green followed by red, while men preferred blue. Results for the circle show a nearly significant preference for red before yellow and blue.

The choice between different forms of the same colour also revealed significant differences: With yellow the circle was preferred, with red the triangle followed by the circle, and with blue the square and the circle. Like the results for German students, the ni-Vanuatu students' preferred blue for the square (about 40 %). Triangle as well as the circle showed no significant differences in colour preferences. For the choice between different forms of the same colour, only the colours red and yellow revealed significant differences: For both colours the circle was preferred by the vast majority (above 60 %).

The investigations confirm Kandinsky's theory of the existence of preferences for certain elementary colour form combinations. The results show context-dependent preferences, yet, mainly different from those proposed by Kandinsky.

Comparing the two culturally different groups, two clear correspondences could be recorded: When observers had to choose between yellow triangle, yellow circle or yellow square, the circle clearly was preferred. When they had to choose between red, yellow, green or blue square, the colour blue was clearly preferred. This may hint at common world knowledge, especially environmental factors as causes of the common aesthetic preferences, e.g. the continuous view of the yellowish circular sun.

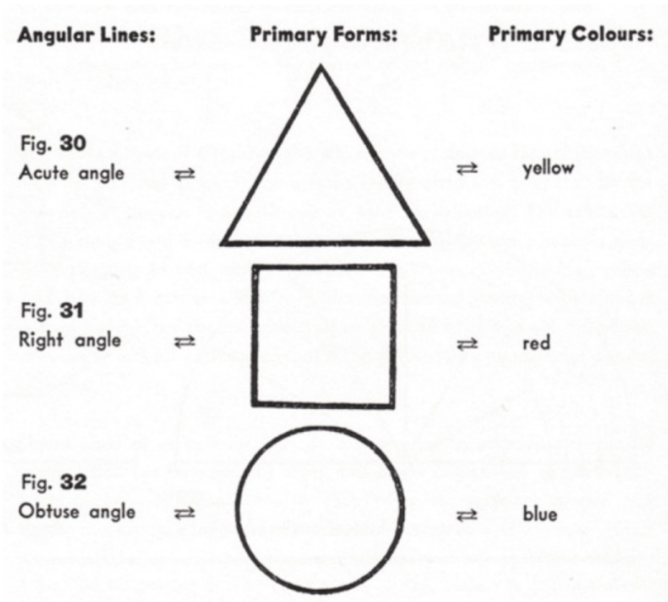

Figure 1: Correspondence of primary forms and primary colours postulated by Kandinsky (1947:74)

References

[1] Kandinsky, W. 1912/1973: Über das Geistige in der Kunst. 10th ed., Benteli, Wabern,.

[2] Wick, R. K. 1994: Bauhaus-Pädagogik. Dumont, Cologne.

[3] Kandinsky, W. 1926/1975: Punkt und Linie zu Fläche. 8th ed., Benteli, Wabern.

[4] Hirschfeld-Mack, L. 1963: The Bauhaus. An Introductory Survey. Longmans, Croydon.

[5] Goldschmidt, R. H. 1927–28: Postulat der Farbwandelspiele. Sitzungsberichte der Heidelberger Akademie der Wissenschaften, Abhandlungen der Philosophisch-historischen Klasse, 6: 1–93.

[6] Jacobsen, T. 2002: Kandinsky's questionnaire revisited: Fundamental correspondence of basic colors and forms? Perceptual and motor skills, 95: 903-913.

[7] Kandinsky, W. 1947: Point and Line to Plane. Solomon R. Guggenheim Foundation, New York.

Colour and touch: cross-modal associations

Oliver Wright[1], Yasmina Jraissati [2]
[1] Bahçeşehir University, Istanbul, Turkey
[2] American University of Beirut, Lebanon

Cross-modal correspondences involve associations across different perceptual modalities. For example, participants reliably pair brighter surfaces with louder sounds and vice-versa[1]. Such associations likely exist between all possible combinations of pairing of sensory modalities[2], though research has mostly focused on auditory and visual correspondences.

Cross-modal associations involving colour have also been documented. One study[3], for instance, reports that children match higher pitched tones preferentially to yellows compared to blues, whilst another found reliable pairings between particular odours and colours[4].

The experiment summarized here focuses on associations between colour and touch. Such associations have recently been reported by a number of studies[5, 6].

Jraissati *et al.* [6] used a task in which participants were shown 64 colour stimuli (a subset of the 330 chip Munsell array that includes colours at the highest saturation level available at each hue and lightness level) one by one and asked participants to match them to haptic and tactile adjectives. The adjectives were presented in opposing pairs *(*e.g., *warm/cool)* and a slider was used to record the degree to which a colour was associated with either of the adjectives in each pair. Results indicated a consistent pattern of associations between the haptic/tactile adjective pairs and colour stimuli. As in previous studies, brightness and saturation of colour stimuli were found to influence participants' responses. Interestingly, some evidence of hue based influences on performance was also found.

One shortcoming of Jraissati *et al's* study (and the other studies of colour touch correspondences mentioned above) is that colours were displayed on an uncalibrated monitor, calling into question the extent to which the colour stimuli matched their supposed Munsell notations. The primary aim of the study reported here is to address this issue and thus to map touch and color correspondences more accurately than has hitherto been attempted.

The basic method was similar to that used by Jraissati *et al.* Stimuli were the same 64 Munsell colours (though presented on chips under controlled lighting conditions) and 10 pairs of opposing adjectives describing haptic/tactile sensations. Rather than asking participants to match adjectives to individually presented colours, we presented all the chips simultaneously on each trial together with one pair of opposing adjectives (e.g. *warm/cool*). Matches made on each trial were recorded. 50 participants took part in the study.

Analysis of the data indicated consistent patterns of matching occurred for all but one of the 10 haptic adjective pairs assessed (*sticky/non-sticky*). For 7 adjective pairs (*soft/hard, smooth/rough, flat/uneven, slippery/not slippery, light/heavy, thick/thin round/sharp*), participants matches were largely influenced by lightness, with one adjective from each pair matched to lighter chips, the other to darker chips. Matches involving the remaining 2 adjective pairs (*warm/cool* and *wet/dry)* were influenced by chip saturation and/or hue: *wet* was consistently matched to blueish chips, *warm* was matched to reddish chips.

The results, are similar to those of previous studies particularly the finding that lightness is the dominant dimension in matching.

Future studies investigating cross-modal correspondences between colour and haptics could profitably focus on several issues. First, in the experiment described above saturation, which varied between individual stimuli, acted as a confound. Consequently, although the experiment enables accurate mapping of touch related adjectives onto the outer surface of the Munsell color solid, it does not enable an assessment of the specific role each separate dimensions of colour (hue, lightness and saturation) plays in task performance. Further studies that hold 2 of the dimensions constant whilst manipulating the third, would allow more detailed understanding of the extent to which each of these dimensions are involved in task performance. Second, speeded classification tasks could be used to investigate the consequences for information processing of the colour/haptic correspondences revealed by matching tasks.

References

[1] Stevens J & Marks L. (1965) Cross-modality matching of brightness and loudness. *Proceedings of the National Academy of Sciences*, *54*, 407-411.

[2] Spence C. (2011) Crossmodal correspondences: a tutorial review. *Attention, Perception, & Psychophysics*, *73*, 971-995.

[3] Simpson R, Quinn M, & Ausubel D. (1956) Synaesthesia in children: association of colours with pure tone frequencies. *The Journal of Genetic Psychology*, *89*, 95-103.

[4] Gilbert A, Martin R & Kemp S. (1996) Cross-Modal correspondence between vision and olfaction: the colour of smells. *The American Journal of Psychology, 109, 335-351.*

[5] Ludwig VU & Simner J. (2013) What colour does that feel? Tactile--visual mapping and the development of cross-modality. *Cortex 49*, 1089-1099.

[6] Jraissati Y, Slobodenyuk N, Kanso A, Ghanem L & Elhajj I. (2016) Haptic and Tactile Adjectives are Consistently Mapped onto color space. *Multisensory Research,* 29, 253-278.

Colours at tabernacle, first and second temples

Mony Almalech
New Bulgarian University, Sofia, Bulgaria

My abstract is motivated by two factors: 1. Examining biblical colours should go forward; 2. Clarifications about my method are needed although my scholarly work is available in academia.edu. Because of a lack of space here, I will skip some of my monograhs, my articles on colour, and most famous data. Details on my hypothesis for decoding the communicative meanings of the sacred Colour tetranom will appear in the paper. The paper examines the colours in the Tabernacle, the First and Second Temples, as they are described in the Hebrew Bible. The norm postulated by Moses consists of the colour Tetranom – blue [tekhèleth], purple [argamàn], scarlet [tolàat šanì], and fine linen [šeš] – and also a few colour binoms. It is a verbal specification with borrowed words, not by accident, for something which should be visual.

The research involves Basic Colour Terms, BCT; Prototypes Terms, PT (e.g. light, darkness, sun, fire, blood, sky, sea, all plants), Prototype Rivals Terms, PRT (e.g. cherry, duckling, ruby, linen, etc.), and Terms for the Basic Features of the Prototypes, TBFP (clean, pure, immaculate for white; hot and warm for fire/blood; fresh for plants, etc.). As colour meaning, BCT are independent, all others are context dependent. This approach corresponds to the current opinion that colour is expressed not only in BCT, e.g. Sutrop [1]. My linguo-semiotic approach includes knowledge of the paradigm of Berlin & Kay, World Colour Survey and their critics; Norms of free association test to BCT for different languages, Prototype Theory of Rosch, Lakoff, Wierzbicka; Theory of translation. I recognise visual and verbal colour, colour as a sign system for communication [2; 3] and articles. In my writings, the term Universality differs from its evolutionary interpretation in the paradigm of Berlin & Kay. I seek to prove that there are non-colour meanings of visual and verbal colours in folk and religion rituals, e.g. purity, clean, immaculate for white; love, hate for red; life, calm for green etc. In the humanitarian tradition these kind of meanings are known as symbolism. Ndembu ritual colours are very good examples in this respect [4]. I claim, unlike Van Leeuwen [5], that there is a colour language, with a small kernel of universal meanings, but it can be observed only in rituals. On the internet, fashion, and everyday life the basic principle is the opposite, just as in the American Indian cultures – 'be different', 'be unique'. I claim that colour language, where it exists, is semantisation and culturisation of Prototypes.

Crucial for this study is knowledge of Hebrew grammar, Jewish history and tradition and the history of Bible translation. This could be framed by Eco's suggestion that colour is a 'cultural unit' [6]. If somebody suffers from ignorance of this point, he/she says that in the Bible (English, or some other -centrism) there is no colour at the noun phrase badgers' skin [or tahašìm]. Badgers is translated in Septuagint ὑακίνθινος (hyacinth-colored). Septuagint is the first translation to another language, which presents Alexandrian Judaism. In case of such ignorance, I can quote St. Jerome's Apology against Rufinus, Book I:

> "Why may not I then discuss about words, and in doing the work of a commentator teach the Latins what I learn from the Hebrews? I should like even now to show you how much profit there is in waiting at the doors of great teachers, and in learning an art from a real artificer. If I could do this, you would see what a tangled forest of ambiguous names and words is presented by the Hebrew."

If someone treats Hebrew colour terms as esoteric, then he/she should think of the Hebrew language as an esoteric language because the extended semantics and etymology of tokens contain meanings indicated in the paper. The same applies to the historical changes in the terminology for linen and BCT. The facts of Hebrew derivation and contexts are disconcerting for most academics who do not know Hebrew, Jewish tradition and culture. Good explanation of these facts is the modern version of the Hypothesis of Linguistic Relativity.

References

[1] Sutrop, U. (2011). Towards a semiotic theory of basic colour terms and the semiotics of Juri Lotman. *New Directions in Colour Studies*, Amsterdam & Philadelphia: John Benjamins Publishing Company, 43-46.

[2] Almalech, M. (1996). *Balkan Folk Colour Language*, Sofia: Sofia University "St. Kliment Ohridski" Press.

[3] Almalech, M. (2011). *Advertisements: Signs of femininity and their corresponding colour meanings*. Sofia: Academic Publishing House "Prof. Marin Drinov".

[4] Turner, V. (1966). Colour Classification of Ndembu Ritual. *Anthropological Approaches to the Study of Religions*. Travistock Publishers, 47-84.

[5] Van Leeuwen, T. (2011). *The Language of Colour. An Introduction*. London & New York: Routledge.

[6] Eco, U. (1985). How culture conditions the colours we see. *On Signs*. Baltimore: Johns Hopkins University Press, 157-175.

[7] Scholem, G. (1974). *Kabbalah*. Jerusalem: Keter Publishing House, Israel.

Screening for jaundice in newborn babies based on sclera colour

Felix Outlaw[1], Terence S. Leung[1], Lindsay MacDonald[2], Judith Meek[3]
[1]Dept. of Medical Physics & Biomedical Engineering, UCL
[2]Department of Civil, Environmental & Geomatic Engineering, UCL
[3]The Neonatal Care Unit, University College Hospital, London

More than half of newborn babies become "yellow" in the first week after birth, a common condition known as jaundice [1]. Jaundice is caused by the accumulation of a yellow chromophore called bilirubin. This happens partly due to immaturity of the liver, where bilirubin is normally metabolised so that it can be excreted. Most jaundice is benign and babies will get better without any intervention. However, in some cases, when the bilirubin level in the blood remains high over time, or becomes excessively high, the baby is at risk of kernicterus, a complication that can cause brain damage. Jaundice can also be caused by life threatening pathological conditions such as neonatal infection, liver diseases, and antibodies from the mother attacking the newborn's red blood cells (haemolytic disease of the newborn). To safeguard newborn babies, jaundice therefore needs to be monitored carefully so that treatments, if necessary, can be administered in a timely fashion.

Jaundice can be monitored by different means, ranging from visual inspection by experienced healthcare workers [2] to transcutaneous bilirubinometers [3] and blood tests. In this work, we introduce an imaging technique that uses a digital camera to capture the sclera colour of newborn babies' eyes and then analyse the image for prediction of the total serum bilirubin (TSB) level. A total of 110 newborn babies participated in the study held in the Neonatal Care Unit of University College Hospital over a two-year period. In this technique, a region of interest in the baby's eye (sclera) was identified in the image. The pixel values inside the region of interest were then averaged for the red, green and blue colours. All 110 sets of averaged pixel colour values and corresponding measured TSB values (by blood tests) were processed by a multilinear regression algorithm based on a quadratic model [4]. Using this regressed model, the predicted TSB values were calculated. The technique has resulted in a linear correlation coefficient of 0.75 ($p<0.01$) between the measured TSB (by blood test) and the predicted TSB (by our imaging technique).

For screening purpose, the technique does not seek to estimate TSB accurately on an individual basis. Instead, it only needs to have a high sensitivity for identifying babies with TSB above a certain threshold. Figure 1, the receiver operating characteristics (ROC) curve, shows that the cut-off threshold can be adjusted to favour a high sensitivity at the expense of a lower specificity. With a cut-off threshold of 162 µmol/l, this technique can identify babies with TSB above 205 µmol/l with sensitivity of 1.00 and specificity of 0.50. In other words, all babies with high TSB (above 205 µmol/l) would be identified although the false alarm is as high as 50%. In fact, it is preferable to identify babies with TSB above 250 µmol/l because this is the level above which the NICE guideline recommends that babies have blood tests to confirm their TSB levels [1]. However, since we do not have sufficient babies with TSB above 250 µmol/l in our database, a lower and more conservative TSB threshold of 205 µmol/l has been used here.

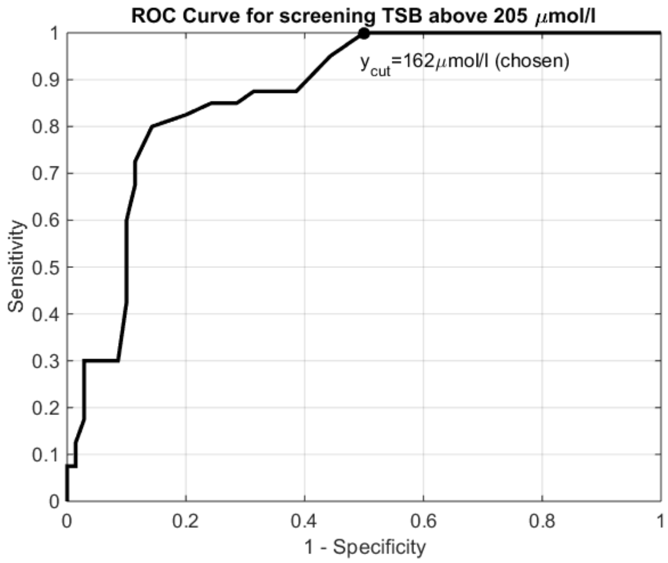

Figure 1 The ROC for identifying babies with TSB above 205 µmol/l: the cut-off threshold (y_{cut}) has been chosen as 162 µmol/l to achieve sensitivity of 1.00 at the expense of a lower specificity of 0.5

Commercial transcutaneous bilirubinometers, such as Bilichek (Philips Healthcare) and Jaundice Meter JM102/JM103 (Draeger Medical Inc.), measure the TSB levels based on the skin colour, which is influenced by the amount of melanin in the skin (ethnicity), and these devices have employed different approaches to minimise this effect. By focusing on the sclera, which is free of melanin, our imaging technique has avoided this major confounding factor in jaundice measurement. We have shown in this work that although currently the imaging technique cannot measure TSB accurately on an individual basis, it has great promise as a screening technique.

References

[1] National Institute for Health and Care Excellence, (2010). *NICE clinical guideline 98: Neonatal jaundice*.

[2] Keren, R., Tremont, K., Luan, X., & Cnaan, A. (2009). Visual assessment of jaundice in term and late preterm infants. *Archives of Disease in Childhood: Fetal and Neonatal Edition,* vol. 94, pp. F317-F322.

[3] Nagar, G., Vandermeer, B., Campbell, S., & Kumar, M. (2013). Reliability of transcutaneous bilirubin devices in preterm infants: a systematic review. *Pediatrics,* vol. 132, pp. 871-81.

[4] Hair, J. F. (2010). *Multivariate Data Analysis*.

Rendering 2D cultural heritage with spatially varying BRDF

Brittany D. Cox, Roy S. Berns
Rochester Institute of Technology. Rochester, New York, United States

A critical aspect of fine art imaging is capturing material appearance aspects, that is, gloss, texture and color. Success requires deep experience and knowledge. This can be very time consuming and inappropriate for rapid capture. A particular challenge is objects with metal and common artist materials. One approach to representing the total appearance of fine art is to take multiple images optimized for each different element of the work and then combine the images using an image-editing software. A second approach, with the potential to save imaging and post processing time, is to image the work using a single set up, described in brief below, and render images using a computer graphics rending software like the commercially available Maya®. This allows the color and surface information captured to be rendered with multiple viewing or lighting geometries that are capable of representing the changes in gloss over the surface of the work without reshooting.

A section of a commode, attributed to Joseph Baumhauer, was imaged using the Four Lights Simplified (4LIS) technique described by Cox and Berns (based on previous work presented by Berns *et al.*) to calculate a color map and surface-normal map.[1, 2] The 4LIS technique requires four different images of the artwork captured using lighting from four different locations. These four different images are used to calculate a surface-normal map using photometric stereo [3] and a diffuse-color map using a thresholding method that mathematically removes highlights.[1] The panel is oak veneered with ebony, set with panels of Japanese lacquer on Japanese arborvitae with Vernis Martin (imitation lacquer), with gilt-bronze mounts.[4]

The color and normal maps are input into Maya using a layered shader. A shader is an element that determines how light reacts when it interacts with the surface. Using a layered shader allows the user to define different properties for different elements of the object, i.e. the gold gilded regions will appear the most glossy from using a shader and settings to mimic the appearance of a metallic surface. Images of the rendered object are shown in Figure 1 from five different lighting directions. The lighting starts from the left of the panel and moves in an arc about its center to the right with the light ending to the far right at a nearly grazing angle. The specific lighting geometry is shown above the rendered image.

Figure 1. Images of the rendered panel with lighting from five different directions showing how the gold areas change differently from the black lacquered areas. The five images are rendered from images taken of Commode (detail), Oak veneered with ebony; set with panels of Japanese lacquer on Japanese arborvitae, painted with Vernis Martin; gilt-bronze mounts; campan mélangé vert marble top (Object: H: 88.3 × W: 146.1 × D: 62.6 cm (2 ft. 10 3/4 in. × 4 ft. 9 1/2 in. × 2 ft. 5/8 in.)) Attributed to Joseph Baumhauer, about 1750, from The J. Paul Getty Museum, Los Angeles.

By creating layers that correspond to different materials used in the piece, renderings can be created that depict the way light would interact with these different materials in the same rendering. The effects of multiple materials being rendered simultaneously can be further emphasized by rendering scenes with multiple lighting configurations to accent the differences in gloss level.

References

[1] Cox, B D, (2015). Imaging artwork in a studio environment for computer graphics rendering. *IS&T/SPIE Electronic Imaging, 9398*, 939803-01-939803-07.

[2] Berns, R S, Chen, T, Wyble, D R, Chen, L, (2012), Update:* Practical Total Appearance Imaging of Paintings*, IS&T Archiving Conference Copenhagen*, *2012*, 162-167.
http://www.cis.rit.edu/DocumentLibrary/admin/uploads/CIS000127.pdf

[3] Woodham, R J, (1980). Photometric Method for determining surface orientation from multiple images, *Optical Engneering*, 19(1), 139–144.

[4] Commode (Getty Museum). (n. d.). Retrieved January 22, 206, from
http://www.getty.edu/art/collection/objects/5359/attributed-to-joseph-baumhauer-commode-french-about-1750/

This research was supported by a grant from the Andrew W. Mellon Foundation.

Computing the object colour solid using spherical sampling

Graham Finlayson[1], Michal Mackiewicz[1], Hans Jakob Rivertz [2]
[1] School of Computing Sciences, University of East Anglia, Norwich, UK
[2] Norwegian University of Science and Technology, Trondheim, Norway

Introduction

In [1, 2], the authors proposed that for the set of N colour systems the spectra located on the boundary of the object colour solid (optimal spectra) are the elementary step functions with the transition wavelengths at $\lambda_1, \ldots, \lambda_m$ if and only if the above set of transition wavelengths are the only zero-crossings of the following equation:

$$k_1 s_1(\lambda) + k_2 s_2(\lambda) + \cdots + k_n s_n(\lambda) = 0$$

where $k_1, k_2, \ldots, k_n$ are the set of arbitrary real numbers, where at least one of them is not equal to zero and $s_i(\lambda)$ are the colour system spectra which are the products of sensor spectral sensitivities $c_i(\lambda)$ and an illuminant spectrum $e(\lambda)$ i.e. $\mathbf{s}(\lambda) = \mathbf{c}(\lambda)e(\lambda)$.

Here, we observe that the components of vector **k** have the geometrical meaning i.e. they constitute the normal vector parametrising the surface of the object colour solid. Because the OCS is convex, in the direction **k**, we can, in closed form, find the unique system response which is maximum. And, from convexity it follows we can find all points on the OCS by extremizing all directions. Formally, we propose the parametric representation with respect to **k** of the surface of the object colour solid.

For a reflectance function $r(\lambda)$ the colour system responses are:

$$\phi_i(r) = \int_{\lambda_{min}}^{\lambda_{max}} r(\lambda) s_i(\lambda) \mathrm{d}\lambda \,, i = 1,2, \ldots, N$$

where λ_{min} and λ_{max}denote the limits of the visible spectrum. A reflectance spectrum $\mathrm{r}(\lambda)$ is a function with values between zero and one. The set of all possible colour system responses form a convex set M called the object color solid in R^N.

We project all colour system responses $\boldsymbol{\phi}(r)$=$(\phi_1(r), \phi_2(r), \ldots, \phi_N(r))$ onto a unit vector **k**. That is:

$$\mathbf{k} \cdot \boldsymbol{\phi}(r) = \int_{\lambda_{min}}^{\lambda_{max}} \mathrm{r}(\lambda) \mathbf{k} \cdot \mathbf{s}(\lambda) \mathrm{d}\lambda$$

It is clear that the maximum value of $\mathbf{k} \cdot \boldsymbol{\phi}(\rho)$ is obtained by:

$$r_{opt} = r(\lambda, \mathbf{k}) = \begin{cases} 0, \mathbf{k} \cdot \mathbf{s}(\lambda) < 0 \\ 1, \mathbf{k} \cdot \mathbf{s}(\lambda) \geq 0 \end{cases}$$

Computing the object colour solid

In this Section, we will assume that the number of colour systems is N = 3, which corresponds to the dimensionality of the human visual system. This said, the algorithm is valid for any number of colour systems. Let us generate a set of M normal vectors in R^3 using a spherical sampling method [3] and store them in the rows of M by N matrix $\mathbf{P}$. We store colour system spectra in N by q matrix $\mathbf{S}$. The wavelength resolution is determined by q e.g. for 1nm resolution, $\lambda_{min} = 380$ and $\lambda_{max} = 730$, the colour system and reflectance spectra will have 351 components i.e. $q = 351$. A matrix resulting from multiplication of $\mathbf{P}$ by $\mathbf{S}$ is denoted as $\mathbf{A} = \mathbf{PS}$ and the signs of its elements determine the set of optimal spectra in matrix **R** as:

$$\mathbf{R}_{ij} = \begin{cases} 0, \mathbf{A}_{ij} < 0 \\ 1, \mathbf{A}_{ij} \geq 0 \end{cases}$$

The procedure described above requires no searching and is very rapid. In Figure 1, we can see 10,000 points on the surface of the object colour solid generated using our method and the convex hull created from these points. The wavelength resolution was 0.1nm and the illuminant spectrum we used was D65.

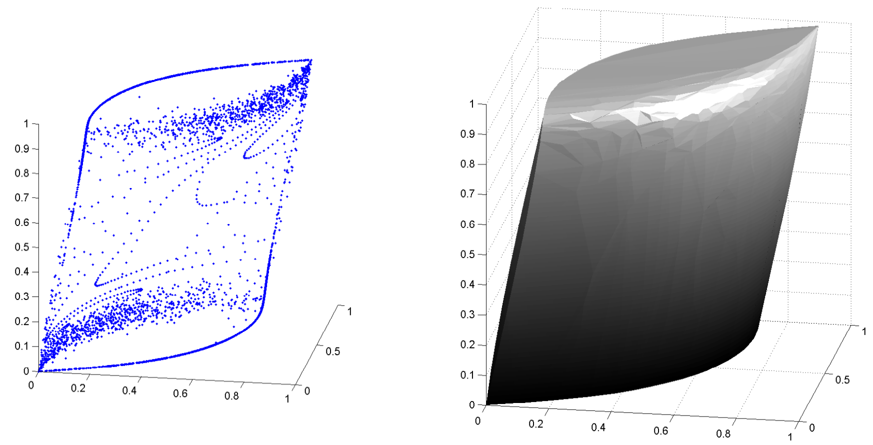

Figure 1. Ten thousand points obtained with our algorithm (left) and their convex hull (right).

Conclusions and future work

We admit that the fast generation of the object colour solid is generally not a significant problem. For example, for the set of three sensors, one could generate a number of sensor responses from the set of randomly generated elementary spectra with two transitions [4, 5]. However, our method allows for describing the solid with a small number of samples and it also allows for any higher number of transitions. Having said that, the main reason for this ongoing work is our intention to use this parametric representation together with the spherical sampling for efficient generation of metamer mismatch volumes, which will be the topic of our next publication.

References

[1] A. Logvinenko, "An object-color space", *Journal of Vision*, vol. 9, no. 11, pp. 1-23, 2009.
[2] A. D. Logvinenko, B. Funt, and C. Godau, "Metamer mismatching", *IEEE Trans. Image Processing*, vol. 23, no. 1, pp. 34-43, 2014.
[3] G. D. Finlayson, J. Vazquez-Corral, S. Susstrunk, and M. Vanrell, "Spectral sharpening by spherical sampling", *Journal of the Optical Society of America A*, vol. 29, no. 7, pp. 1199-1210, 2012.
[4] C. Godau and B. Funt, "XYZ to ADL: Calculating Logvinenko's Object Color Coordinates", in *Proceedings of the 18th Color and Imaging Conference (CIC)*, 2010.
[5] G. Finlayson, M. Mackiewicz, and A. Hurlbert, "Making calculation of Logvinenko's coordinates Easy", in *Proceedings of the 20th Color and Imaging Conference (CIC)*, Los Angeles, Nov 2012

A systematic review and meta-analysis of the evidence on whether deuteranomaly places children at a disadvantage in educational settings

Beejal Mehta, Paul Sowden
School of Psychology, University of Surrey, UK

Colour vision deficiencies (CVD) affect 8% of males and 0.4% of the female population of Caucasian ethnicity [10], with a reported lower prevalence for other races. The highest prevalence is for deuteranomaly, which is a type of anomalous trichromatic vision in which the medium wavelength cones have reduced sensitivity. This affects 5% of males and 0.35% females.

There has been a longstanding and lively debate concerning childhood colour vision screening. The UK National Screening Committee (NSC) governs 'Childhood Vision Screening' strategy. Whereas visual defects such as amblyopia, refractive error and strabismus are currently being screened at school entry, CVD screening is not (at the time of writing). This is because several researchers have stated that children with colour vision deficiencies are at no functional disadvantages in relation to educational achievement [1, 8]. In contrast, recent research has shown that the perception of colour can affect performance on tasks specifically set in an achievement context [2,7,3]. Further, Italian students with CVD were found to achieve lower grades in general school assessments (excluding art) than their peers with normal colour vision [5]. Torrents, Bofill and Cardona (2011) stated that certain Spanish school textbooks need to be redesigned through an alternative use of colours and textures to take into consideration individuals with CVD's. In line with this suggestion, many contacted editorial boards have committed to undertake the appropriate changes.

As well as the debate about whether CVD's have any impact on educational attainment, it is important to consider other effects that CVD's may have on children's adjustment to and development within a school context. Children approach school with a diversity of individual experiences, attitudes, expectations and developmental differences [4]. They are potentially vulnerable at this developmental stage as they are facing not only progressive challenges but also having to adapt to a new environment, routine and people. One of the means of creating a stress-free transitional bridge, is to conduct various screening programmes upon school entry, so that schools can make various adaptations for children with disabilities and/or deficiencies hoping that their learning and socializing abilities will increase [9, 11, 6]. Thus, it may be important to consider whether CVD's have any impact on other outcomes such as social adjustment in addition to assessing impact on educational attainment.

Given the conflicting evidence, it would seem valuable to systematically evaluate the evidence in order to inform decisions about whether colour vision screening assessments should be performed within UK primary schools. Consequently, we will report here a systematic review and meta-analysis of the evidence that explores the question "Does deuteranomaly have any effect on academic attainment and psychosocial well-being in a school context?". A literature search related to this question will be conducted by searching PuBMed, Scopus, Psychinfo, Child Development & Adolescent Studies and Education Resource Information Centre (ERIC) for papers that combine words related to Colour vision (English and American spelling; e.g. colour vision deficits (i.e. dichromats and anomalous trichromats), the way we view colour (e.g. colour perception, colour discrimination, colour thresholds) and colour vision tests/screening (e.g. Ishihara, pseudoisochromatic tests, Colour vision testing made easy – CVTME etc), with words relating to educational (e.g. learning) or psychosocial (e.g. well-being) outcomes. In addition, relevant unpublished literature will be sought through personal contacts of the authors and calls via popular mailing lists (e.g. CVNet, Visionlist). Inclusion criteria will include: Journal articles, peer-reviewed and non-peer reviewed conference proceedings and unpublished literature, from 1990 until the present day; sample includes children, pupils or students. Exclusion criteria will include: Non-english language articles, book reviews and literature articles prior to 1990. The abstract of the sourced literature will be screened for relevance and further 'hand' searches will be conducted from the reference lists of included articles to identify any further, relevant articles. Selected papers will then be read in full and rated for quality using pre-determined criteria. Finally, effect sizes will be extracted and included in a meta-analysis that determines the current strength of evidence that colour vision defecincies affect educational and/or psychosocial outcomes in a school context. This will inform the debate about whether colour vision screening should be routinely included within schools.

References

[1] Cumberland, P., Rahi, J. S., Peckham, C. S (2004) Impact of congenital colour vision deficiency on education and unintentional injuries: findings from the 1958 British birth cohort. *British Medical Journal*. 329(7474), 1074-1075.

[2] Elliot, A., Maier, M., Moller, A., Friedman, R., Meinhart, J. (2007). Colour and psychological functioning: the effect of red on performance attainment. *Journal of Experimental Psychology.* 136(1), 154-168.

[3] Elliot, A., Aarts, H. (2011). Perception of the colour red enhances the force and velocity of motor output. *Emotion*. 11(2), 445-449.

[4] Fabian, H. (2012). Children starting school. New York: Routledge.

[5] Gallo, P. G., Oliva, S., Lantieri, P. B., Viviani, F. (2002) Colour blindness in Italian art high school students. *Perceptual and motor skills*. 95(3); 830-834.

[6] Lochman, J. E. (1995). Screening of child behavior problems for prevention programs at school entry. *Journal of consulting and clinical psychology*. 63(4): 549-559.

[7] Mehta, R., Zhu, R. (2009) Blue or Red? Exploring the effect of colour on cognitive task performance. *Science*. 323(5918), 1226-1229.

[8] Ramachandran, N., Wilson, G. A. (2014) Is screening for congenital colour vision deficiency in school students worthwhile? A review. *Clinical and experimental optometry*. 97(6), 499-506.

[9] Saine, N. L., Lerkkanen, M., Ahonen, T., Tolvanen, A., Heikki, L. (2011). Computer assisted remedial reading intervention for school beginners at risk for reading disability. *Child Development*. 82(3), 1013-1028.

[10] Torrents A., Bofill F., Cardona, G. (2011). Suitability of school textbooks for 5-7year old children with colour vision deficiencies. *Learning and individual differences*. 21(5), 607-612.

[11] Williams, C., Northstone, K., Harrad, R. A., Sparrow, J. M., Harvey, I. (2003). Amblyopia treatment outcomes after preschool screening v school entry screening: observational data from a prospective cohort study. *British journal of ophthalmology.* 87(8): 988-993.

Day #3 – Friday 16th September

Session 8: Colour Perception

A neural signature of the unique hues

Lewis Forder[1], Jenny Bosten[1], Xun He[2], Anna Franklin[1]
[1] School of Psychology, University of Sussex, Falmer, UK
[2] Faculty of Science and Technology, University of Bournemouth, Poole, UK

For more than five hundred years there has been the idea that there are four phenomenologically simple and pure "unique" hues [1]: red, yellow, green, and blue. It is claimed that unique hues are elemental qualities of color appearance because they cannot be described in terms of any other hue, and that all other hues can be described as mixtures of the unique hues [2]. Unique hues are also central to classical theories of color vision such as Hering's 'opponent process theory' [3] and modern models of color appearance [4]. The special status of unique hues has been described as 'one of the central mysteries of color science' [5]. Finding neural support for the unique hues remains a key objective in contemporary neuroscience.

The current study aimed to reveal a neural representation of the unique hues by measuring event-related potentials (ERPs) elicited in response to eight different hues: the four unique hues and the four intermediate hues (orange, lime, teal, and purple). ERPs are waveforms of neural activity that are recorded from the scalp with electrodes and are time locked to an event, such as a color being shown. We firstly accounted for individual variation in the positions of the unique and intermediate hues (i.e., hue angle) by adopting a psychophysical task. For each observer (N = 23) we then measured the electrophysiological activity elicited in response to their specific unique and intermediate hues. We analyzed the peak latencies (ms) and mean amplitudes (µV) of each of the eight hues in three visual ERP components (P1, anterior N1, and posterior P2).

In order to account for the non-uniform effect of position in color space of each stimulus, for each ERP component we fit ellipses to each observer's peak latency (r) and mean amplitude (r) as functions of hue angle (ϑ). We then found the residuals for each data point to a best-fitting ellipse. This is equivalent to the difference in peak latency or mean amplitude for a particular hue compared to what would be expected from that hue's position in color space (see Figure 1a). A hue with a positive residual indicates that the peak latency is later or the mean amplitude larger than expected. This method follows that used by [6].

Our key result concerns the latency of the posterior P2 component: a Friedman test revealed a significant main effect of hue, χ^2 (7) = 27.5, p = .00027, which was associated with a difference between the grouped unique compared to the grouped intermediate hues, Z = -2.9, p = .004, (see Figure 1b). Specifically, the residuals for all four unique hues are negative (meaning that the posterior P2 occurs earlier than expected). We found no significant main effect of hue on mean amplitude for any component.

We find a neural signature of the unique hues that exists 230 ms after a color is presented. There was no indication for a neural marker for the unique hues in earlier components (i.e., the P1 and anterior

N1). This finding provides a platform for future research to address fundamental questions about the origin of the unique hues, such as whether they are explicitly a linguistic phenomenon [7], whether they develop due to familiarity with natural color statistics and/or daylight illuminants [8], or whether the social environment confers the unique hues' special status through linguistic and cultural consensus [9].

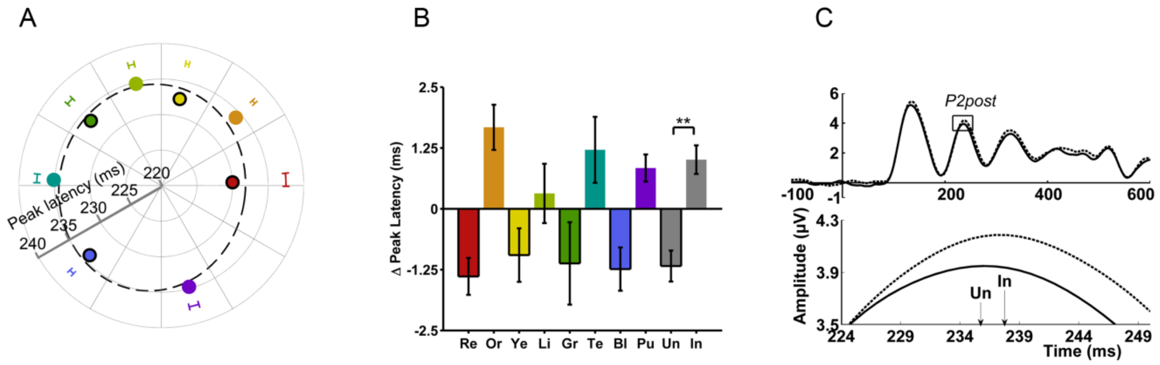

Figure 1. A neural marker of the unique hues in the peak latency of the posterior P2 ERP component. The four unique hues are denoted with solid black borders. The four intermediate hues do not have borders. (**A**) Data averaged across observers and depicted as a polar plot showing peak latency (*r*) as a function of median hue selection (*ϑ*). The unique hues all fall inside a best-fitting ellipse applied to the data (dotted black line) showing that they all peaked earlier than would be expected for their location in color space. (**B**) Group mean residuals of the positions of each hue from the best fitting ellipse. The combined mean Unique (Un) and Intermediate (In) residuals are shown in grey. Error bars are ± 1 SEM. (**C**) Representative ERP waveforms averaged across observers from electrode Oz for the unique hues (solid line) and the intermediate hues (dotted line). The posterior P2 component is indicated by the surrounding box (top). The data inside the box are also presented separately (below).

References

[1] da Vinci, L (1651/1906). A Treatise on Painting. Translated to English by JF Rigaud (George Bell & Sons, London).

[2] Sternheim, CE, Boynton, RM (1966). Uniqueness of perceived hues investigated with a continuous judgmental technique. *Journal of Experimental Psychology, 72*, 770.

[3] Hering, E (1878). Outlines of a theory of the light sense *(Translated by Hurvich, L. M. & Jameson, D.)* (Harvard University Press, Cambridge).

[4] Hård, A, Sivik, L (1981). NCS—Natural Color System: A Swedish Standard for Color Notation. *Color Research and Application, 6*, 129–138.

[5] Mollon, JD, Jordan, G (1997). On the nature of unique hues. *John Dalton's Colour Vision Legacy* (Taylor & Francis, London), pp 381–392.

[6] Witzel, C, Gegenfurtner, KR (2013). Categorical sensitivity to color differences. *Journal of Vision, 13*, 1–33.

[7] Davies, IR, Corbett, GG (1997). A cross-cultural study of colour grouping: Evidence for weak linguistic relativity. *British Journal of Psychology, 88*, 493–517.

[8] Mollon, JD (2006) Monge: the verriest lecture, Lyon, July 2005. *Visual Neuroscience, 23*, 297–309.

[9] Webster, MA, et al. (2002). Variations in normal color vision. III. Unique hues in Indian and United States observers. *Journal of the Optical Society of America A, 19*, 1951–1962.

Ensemble perception: can humans estimate average colour?

John Maule, Anna Franklin
The Sussex Colour Group, University of Sussex, Brighton, United Kingdom

The world is full of visual information which we must use to make decisions, identify objects and navigate the world. Colour can be a very informative signal for helping us rapidly understand our environment. For example, we can quickly and effortlessly use colour to tell whether a tree is in summer or autumn, identify groups of fans in a stadium, or identify which bunch of bananas on a market stall is the ripest. The number of items present in such scenes is substantially above the proposed limits of visual working memory [1]. Thus, in order to make such judgments the brain must find a way to efficiently represent these sets.

The brain may represent the summary statistics of the features of a set of objects in favour of individual item representations. It has been shown, for example, that people can extract the mean size of a set of items very efficiently [e.g., 2]. Similarly it has been found that people can estimate the average facial expression or facial identity of a crowd, even when viewed for a very brief time [e.g., 250ms, 3]. One hallmark of these experiments is that when their memory is tested observers typically have a very poor idea of exactly which items were in the set, yet retain an idea of the gist – a summary representation. This phenomenon has been called ensemble perception.

We present data from a series of experiments on ensemble perception of hue characterising the human ability to visually average different colours. These experiments sought to: i) demonstrate whether humans showed a tendency to average hue given brief exposure to arrays of coloured patches (ensembles); ii) investigate the limits of hue averaging with regard to the complexity and variation in colour; iii) measure the precision with which the average colour could be reproduced; and, iv) investigate the effects of colour categories on hue averaging.

In the first study [4] we tested participants' memory for the specific colours presented in an ensemble visible for 500ms. Although it was never a part of any ensemble, the participants tended to think they had seen the mean hue, finding it as familiar as the actual ensemble colours. Manipulating the categorical similarity of the ensemble elements, by showing participants ensembles of blues and greens, had no effect on the tendency to recognise the mean hue. However, this mean effect did disappear when the ensemble colours were more different from one another. This suggested that summary statistic encoding of colour might be occurring, but may also be limited by the range of colours in the scene.

The second study [5] showed that participants' ability to pick a mean colour for a rapidly-presented ensemble from a two-alternative forced-choice (2AFC) was stable regardless of how many elements they were required to average across. This may be supportive of a holistic-averaging account of ensemble perception [e.g., 6, 7, 8]. Again, the range of colour in an ensemble limited the accuracy of average hue choices, suggesting that the circularity of hue space might be a problematic feature of perceptual averaging for colour.

In the third study [9] we used the method of adjustment to estimate the precision of participants' estimations of the mean hue. Although we found that responses tended to peak at the expected mean hue, a subsequent ideal observer simulation [e.g., 3] suggested that this could be the result of a focused-attention strategy whereby most participants could just be focusing their attention on one or two elements, rather than taking in the whole ensemble.

Finally, we report an experiment showing that autistic adults have a somewhat different pattern of ensemble perception of hue compared to typical adults. Performance on both member identification and mean selection tasks are consistent with a bias towards processing of local detail in autism, but intact global summary statistical representations of the mean colour.

These experiments have shown that the human ability to quickly extract the average of a colourful set of items shares many aspects of that found in other visual domains like size and faces. However, the process shows a tendency to break-down when ensembles contain a wide range of hues. Likewise the precision of mean estimates suggests that a sub-sampling mechanism or strategy could suffice to explain the mean extraction ability of observers. Hue may be uniquely difficult to average when compared to other domains, which may have implications for the role of colour in gist perception.

Supported by the Economic and Social Research Council (ES/J500173/1) and European Research Council grant 'CATEGORIES' (283605).

References

[1] Alvarez, GA, (2011). Representing multiple objects as an ensemble enhances visual cognition, *Trends in Cognitive Sciences*, *15*, 122-131

[2] Ariely, D, (2001). Seeing sets: Representation by statistical properties, *Psychological Science*, *12*, 157-162

[3] Haberman, J & Whitney, D, (2010). The visual system discounts emotional deviants when extracting average expression, *Attention Perception & Psychophysics*, *72*, 1825-1838

[4] Maule, J, Witzel, C & Franklin, A, (2014). Getting the gist of multiple hues: metric and categorical effects on ensemble perception of hue, *Journal of the Optical Society of America A*, *31*, A93-A102

[5] Maule, J & Franklin, A, (2015). Effects of ensemble complexity and perceptual similarity on rapid averaging of hue, *Journal of Vision*, *15*, 1-18

[6] Ariely, D, (2008). Better than average? When can we say that subsampling of items is better than statistical summary representations?, *Perception & Psychophysics*, *70*, 1325-1326

[7] Corbett, JE & Oriet, C, (2011). The whole is indeed more than the sum of its parts: Perceptual averaging in the absence of individual item representation, *Acta Psychologica*, *138*, 289-301

[8] Im, HY & Halberda, J, (2013). The effects of sampling and internal noise on the representation of ensemble average size, *Attention Perception & Psychophysics*, *75*, 278-286

[9] Maule, J & Franklin, A, (2016). Accurate rapid averaging of multihue ensembles is due to a limited capacity subsampling mechanism, *Journal of the Optical Society of America A*, *33*, A22-A29

The role of saturation in colour naming and colour appearance

Christoph Witzel[1, 2]
[1] Université Paris Descartes, Paris, France
[2] Justus-Liebig-Universität Gießen, Gießen, Germany

Saturation, chroma and colourfulness (here shortly "saturation") refer to the difference of a colour from achromatic colours, such as black, white, and grey. How a beholder perceives the saturation of colours is an integral part of colour perception. Yet, saturation has been widely neglected in the investigation of colour naming and colour appearance. The present investigation provides four lines of evidence for the important role of saturation in colour naming and colour appearance.

First, typicality and category membership depend on saturation because saturation distinguishes chromatic from achromatic categories (e.g. Figure 8 in 1). Seminal studies that observed regularities in colour categorization across languages used stimulus sets of Munsell chips that have particularly high saturation around category prototypes. The variation of saturation across the stimulus set is correlated to colour naming and prototype choices across languages [2-4]. Consequently, observed cross-cultural patterns in colour categorization might well be due to the unequal distribution of saturation in stimulus samples.

Second, a correspondence between unique hues and the most typical red, yellow, green, and blue would establish a direct relationship between colour appearance and colour naming. However, evidence for a relationship between unique hues and typical colours is ambiguous. Observed incongruences between category prototypes and unique hues may be due to different effects of saturation on the measurements of prototypes and unique hues. In contrast to typicality, instructions for unique hue measurements might push observers to discount for variations in saturation. When controlling saturation across hues there is no difference between category prototypes and unique hues [3, 5]. These results suggest that unique hues and the typical hues of the red, yellow, green and blue categories are equivalent.

Third, several studies have observed perceptual particularities for typical and unique red, yellow, green, and blue, such as "optimality" and "perceptual salience", "perceptual prominence", "sensory singularity" and high colour constancy. These properties may be explained by the peak of saturation around pure red, yellow, green, and blue in the classical stimulus set of Munsell chips [2, 3]. However, the peaks of saturation around those colours are a peculiarity of the stimulus set rather than a perceptual property of the human visual system [3, 5]. Consider Figure 1 for illustration. Additionally, there is no evidence that typical red, yellow, green, and blue are more colour constant than others when controlling for saturation [6]. Hence, it is highly questionable whether English prototypes have perceptual characteristics that qualify them as culturally universal "focal colours".

Finally, the original idea that any apparent colour is composed by the mixture of chromatic and achromatic unique hues requires that saturation is at least as high for unique as for non-unique, intermediate hues (cf. Figure 1). However, there are intermediate hues that can reach higher levels of saturation than any of the unique hues [3, 5]. It is not clear how these intermediate hues may be mixed by unique hues if such a mixture cannot reach the level of saturation of the intermediate hues.

Taken together, these findings highlight the importance of controlling saturation in research on colour naming and colour appearance. Moreover, they raise important questions about the "focality" and "uniqueness" of red, yellow, green and blue.

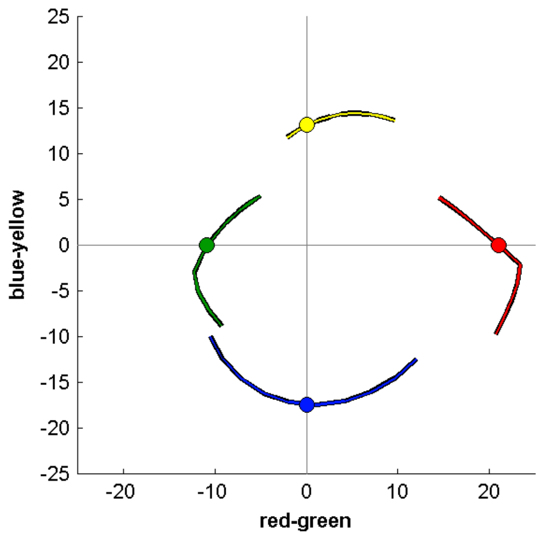

Figure 1. Maximum perceivable saturation for red, yellow, green, and blue. The graphic illustrates the idea of opponent unique hues based on empirical measures of hue and saturation. The azimuth in this space is based on hue in CIELUV, which has been shifted so that the axes correspond to unique red, yellow, green and blue. Eccentricity has been scaled by empirical estimations of perceivable saturation (cf. [3]). Curves show maximum perceivable saturation at the visible gamut for a range of hues around unique red, yellow, green, and blue (coloured discs). Note that non-unique intermediate hues can reach higher saturation (eccentricity) than adjacent unique hues (yellow, red, and green).

References

[1] Olkkonen M, Witzel C, Hansen T, & Gegenfurtner KR (2010) Categorical color constancy for real surfaces. *Journal of Vision* 10(9):1-22.

[2] Witzel C, Cinotti F, & O'Regan JK (2015) What determines the relationship between color naming, unique hues, and sensory singularities: Illuminations, surfaces, or photoreceptors? *Journal of Vision* 15(8):19.

[3] Witzel C, Maule J, & Franklin A (under revision) Are red, yellow, green and blue particularly "colorful"?

[4] Witzel C (in press) New insights into the evolution of colour terms or an effect of saturation? *i-perception*.

[5] Witzel C & Franklin A (2014) Do focal colors look particularly "colorful"? *Journal of the Optical Society of America. A, Optics, image science, and vision* 31(4):A365-374.

[6] Witzel C, Van Alphen C, Godau C, & O'Regan JK (in press) Uncertainty of sensory signal explains variation of colour constancy. *Journal of Vision*.

Art, interpersonal comparisons of color experience, and potential tetrachromacy

Kimberly A. Jameson[1], Keith Goldfarb[2], Vladimir Bochko[3]
[1] University of California at Irvine, Irvine, USA
[2] Blackthorn Media LLC, Los Angeles, USA
[3] University of Vaasa, Vaasa, Finland

Artistic representation of naturalistic scenes makes use of a range of visual processing features, and color and illumination are two that are frequently employed as strong dimensional emphases, especially in the medium of painting. Variations in human retinal photopigment classes are known to effect perception of light and color, and produce color appearance processing differences across individuals. We empirically investigated color perception in genotyped individuals with a potential for greater than three retinal photopigment classes compared to controls. We investigate both professional artists and non-artist participants using psychophysical designs that employed low-level motion processing of isoluminant color stimuli. Psychophysical results are used to design image-processing filters to identify components of visual scenes processed differently by potential tetrachromat observers. One filter converts values of psychophysically observed differences into a color scale, providing a first-order approximation of how inter-observer variation may impact spatial and chromatic features of natural scene processing. These simulations provide informative visualizations, across a range of scenes, allowing a normal trichromat observer to note specific portions of visual scenes that a potential tetrachromat observer may uniquely experience, and, suggest what portions of a scene a potential tetrachromat artist may be expected to paint in a uniquely artistic manner.

Keynote Lecture #4

Wayfinding in Colourland

Jan Koenderink
University of Leuven (KU Leuven)

Colours are qualities of imagery. With your eyes open, in front of a daylight scene, you often confuse them with physical entities. The latter belong to reality – are conceptual, like "photons" or "electromagnetic fields". Colours belong to actuality, are concrete – like "itches" or "feelings". To take reality as the cause of actuality is a common confusion that reverses the natural order. Reality is an abstraction from shared, thus "objective", concrete actualities – that is science. Actuality is current awareness, thus subjective. In simplified laboratory setups the structure of radiant power may become a major cue for colour and allow one to engage in psychophysics. Otherwise cues for colour depend on spatiotemporal and radiometric structures, as well as familiarity with the natural environment. This is the realm of experimental phenomenology. One would welcome roadmaps to Colourland and useful aids to wayfinding and orientation. Fortunately, the history of science and art offers plenty of leads. I'll discuss the landscape – statistics of natural colors, landmarks and navigational aids.

Session 9: Colour and Environment

Potential uses for spectrally variable lighting in museum environments

Danny Garside[1], Lindsay MacDonald[1], Kees Teunissen[2], Katherine Curran[1], Capucine Korenberg[3], Stuart Robson[1]
[1] UCL, London, UK
[2] Philips Lighting Research, Eindhoven, The Netherlands
[3] British Museum, London, UK

In museum environments current practice is to specify lighting with a high Colour Rendering Index (CRI) [1,2], producing object colours which can be considered as roughly faithful representations of how the objects would appear under natural illumination, or artificial illumination of a rudimentary nature such as candlelight or tungsten filament. Whilst this could serve one potential aim for museum lighting, we ask here how other aims might be served, especially if spectrally variable lighting is considered.

In Viénot's 2011 paper [3] a procedure was presented for enhancing the appearance of faded objects, such that they might better resemble their original appearance. This procedure was demonstrated using a pair of Galapagos finch specimens (from the Muséum national d'histoire naturelle collection) of different ages, such that the older (and more faded) of the pair was made to resemble the newer specimen. This was accomplished through the use of LED combinations which induced predictable colorimetric shifts. Notably, the lights used to create this effect were spatially homogenous (as opposed to other visual restoration projects, see Rothko restorations and Hampton Court Palace tapestry restoration [4]) and metameric to a broadband phosphor white LED. Such lighting would differ from a natural light source by design, and consequently have a lower CRI value.

Whilst still in some ways representing the notion of fidelity, the difference here is that original colours are the target, instead of current colours. This movement away from colour fidelity as it has traditionally been used raises some interesting questions about representation of objects in museums, and the role of museums in making choices regards representation. If an object can appear as it was originally intended, should it be displayed as such? What if displaying it as such was incrementally more damaging to the object, and would shorten its usable life span? Even for the display of modern materials, such lighting has been shown to be preferable in some situations, for its ability to render colours more saturated than would be the case under natural illumination [5,6] and more in keeping with our memories of previously seen colours [7]. The possibility that preferred CCT is object specific has been explored [6].

Currently the cost of using spectrally optimised lighting, both in general and where individual variations are considered on an object-by-object basis, is prohibitive. But it is conceivable that in the near future this type of lighting could become practicable, and it is prudent to consider the potential of the increased flexibility offered by such configurable lighting, in advance of its availability. If one had access to such equipment at a reasonable price, how would it be best used in a museum environment? It is already quite possible to procure light sources which can render specific object colours as more saturated than a reference light source would, but these light sources will have a low colour rendering index, because of the colour distortion they cause. Use of a 'gamut area' type index might help to describe these light sources better, but the specific colours affected would still not be described.

The potential for using spectrally variable lighting in museums to control colour rendering, beyond fidelity, is broad, and warrants consideration. Questions about the role of museums in representing 'truth' are raised by the potential flexibility that spectrally variable lighting provides. The ability of museum curators to cater for aims such as those discussed above will be much enhanced by the development of appropriate colour rendering indices.

References

[1] Chartered Institution of Building Services Engineers. *Lighting Guide 8: Lighting for Museums and Art Galleries.* London: Society of Light and Lighting : CIBSE, 2015.

[2] Museum of London. *Museum of London Lighting Policy*. Advanced draft (2016)

[3] Viénot, F., Guillaume C., and Bertrand L., (2011). "LEDs as a Tool to Enhance Faded Colours of Museums Artefacts", *Journal of Cultural Heritage 12, no. 4:* 431–440. doi:10.1016/j.culher.2011.03.007.

[4] Hecht, J., (2015). "Light Repairs Art: Optical Overlays Restore Faded Masterworks." Optics and Photonics News 26, no. 4: 40. doi:10.1364/OPN.26.4.000040.

[5] Ohno, Y., Fein, M., and Miller, C., (2015) "Vision Experiment On Chroma Saturation For Color Quality Preference", CIE Proceedings, 28th Session. Proceedings Volume 1. Part 1. CIE 216:2015 ISBN 978-3-902842-55-8

[6] Liu, A., Tuzikas, A., Zukauskas, A., Vaicekauskas, R., Vitta, P., Shur, M., (2013) "Cultural Preferences to Color Quality of Illumination of Different Artwork Objects Revealed by a Color Rendition Engine", *IEEE Photonics Journal 5, no. 4*: 6801010 doi:10.1109/JPHOT.2013.2276742.

[7] Bartleson, C., (1960)"Memory Colors of Familiar Objects", *Journal of the Optical Society of America 50, no. 1*: 73. doi:10.1364/JOSA.50.000073.

Red on Red

Esther Hagenlocher [1], E. Landry Smith [2]
[1] University of Oregon, Eugene, OR, U.S.A.
[2] Landry Smith Architect, Portland, OR, U.S.A.

This research project is based on a temporary, experimental proposal for the International Garden Festival at Les Jardins de Métis in Grand-Metis, Quebec, Canada. Building upon Josef Albers' seminal primer on color theory, *Interaction of Color* [1], the garden seeks to establish a framework to experience color perception and sensation in a larger field (Figure 1).

Figure 1. Garden entrance

The interaction of color is valuable aesthetically and in terms of performance. The effect of color can be increased without changing people's perceptions of the color in the space, by applying the interaction of color with the larger built environment in nature.

The proposed research focuses on the connection between design principles and color interaction in order to develop understandings as to how to optimize spatial efficiency, performance, and visual comfort, and yet this research also looks to find potentials for colors to expand upon, confuse, conceal, and to misrepresent built three dimensional form.

Given the qualities of color interaction, why are spaces not typically designed with a set of these? To test the hypothesis, the perception of color interaction will be assessed empirically. Stepping outside the white cube, and outside of Albers' color experiments, how does color interact? The color sequence appears to advance counter to its planometric organization or spatial ordering generated by the colors because of the larger areas of color that appear in perspective on the lower boarders. This effect was discovered by Albers and articulated by his student Lois Swirnoff[1] [2].

Future research will focus of the development of physical models that testing the interaction of color within larger environments. The models will explore color interaction by using a range of graphic techniques to maximize the relative appearance of a color in relation to adjacent colors when these fields are interspersed (Bezold). Guiding Research Questions and Experiments:

- Can we achieve the perception of intense colors while also providing little color?
- How can space be colorful without using much color? Moreover what is the minimum required?
- What is a strategy for color interaction in nature - with the plants, the sky, the seasons? How to apply the Interaction of Color to conditions that are in a constant state of flux?
- Building on El Lssitzky and Theo van Doesberg, are there other ways to challenge the primacy spatial form? In what ways can the use of color alter or deny three dimensional space?
- Can spatial composition and color be at once independent and dependent systems? How to minimize and maximize the optical destruction of volumes and forms in space?

Investigation of these effects will be looked at in a context of variables, including daylight, shadow, background conditions and colors, and the position of the viewer. The following issues will serve as key points of investigation:

- The outline and definition of space through color. And conversely the undermining of architectural space through color application.
- Spatial effects of color including compression, extension and resolution of volumes.
- Connection and disconnection of spatial elements by color.

These initial experiments showed that color is a dynamic and highly subjective element. Contrary to its often ascribed secondary role in architecture, color has powerful dimensional potential on par with form itself. These experiments underscore the ongoing significance of Albers' body of work and the continuing relevance of his color experiments.

Color in interior spaces is well documented, as is the artistic role of the interaction of color. However, the connection between space and the interaction of color and more generally color in the built environment outside needs to be further explored through empirical research.

Further testing will be done to determine how position affects the perception of color. Our hypothesis is that the significance of color interaction in both interior and exterior space can be achieved through minimal means and subtle alternation of hue, brightness, reflectivity, and color sequencing.

References

[1] Albers, Josef (1963). *Interaction of Color*. New Haven: Yale.

[2] Swirnoff, Lois (1988). *Dimensional Color ("A pro scientia viva" title).* Boston; Basel: Birkhaeuser.

[1] "The illusion of spatial advancing or receding with perceptually mixed colors can be reinforced or diminished by their placement within the vertical/ horizontal frame of reference. When seen as concentric groupings, with all intermediate areas appearing equal in size, the spatial effect is diminished βψ τηειρ πλαχεμεντ ωιτηιν τηε ϖερτιχαλ/ ηοριζονταλ φραμε οφ ρεφερενχε." —Dimensional Color p. 44."

Session 10: Colour and Architecture

A phenomenological approach to colour surveys in architecture

João Pernão[1,2]
[1] CIAUD – Research Centre for Architecture, Urbanism and Design, University of Lisbon, Portugal
[2] APCOR – Portuguese Colour Association

A survey is the stable foundation for any colour study in Architecture, regardless of it being aimed at a restoration project, at a new building or at an urban rehabilitation process. Technical surveying processes and methodologies related to the material surface composition and its colours have long been discussed, but few things have been seriously stated about the importance and the benefits of a phenomenological approach at this stage that could complement the site information and give other clues to a more adequate intervention.

Figure 1. How can we transmit the emotional atmosphere of a certain place?

The aim of this paper is to state the importance of a phenomenological approach that can gather the perceptual permanent and non–permanent characteristics of the object of study and its environment, bringing together, define and illustrate, different concepts to complement the standard approach to colour survey: Landscape, Townscape, Image of the City, Synaesthesia, Colourscape, Geography of Colour, Colour Loci, Emotional Atmosphere, Light and Time. Beside the colour phenomenon field, these concepts emerge from the realm of Architecture, Phenomenology and Perception.

a) *Landscape*: the etymological root of the word points to “the form of the land” (land+shape). More than with form, which is of course very important to the site characterisation, we should deal with the presence of elements of Nature (type of stone, type of vegetation, etc.) as well as with important geographical features, like Orientation and Latitude/Longitude, which can give us different ambiences derived from the solar incidence, temperature, humidity, etc.

b) *Townscape* is a concept created in Gordon Cullen’s book with the same name [1] defining and organizing the quality of cities through certain perceptual concepts. One that is especially useful for this type of survey is the Serial Vision: the sequence of perceptual revelations or happenings in the street narrative that shows when we walk or drive through the urban space.

c) *Image of the City* is a phenomenological approach created by Kevin Lynch [2], relating architecture with the mental image of the city that we establish in our minds. This idea extends the notion of Townscape to the importance of sense’s synaesthesia, and to the *legibility* of the urban space.

d) *Synaesthesia*: comes from Ancient Greek words *syn+aisthēsis* (*together+sensation)* meaning a simultaneous stimulation of two or more senses due to a sensory input. The idea that every architectural experience could derive from many senses, and not just the sight, is very important to our study. Juhani Pallasmaa [3] developed this idea by putting it in contrast with the concept of *image*, which Heidegger called the fundamental event of the modern age.

e) *Colourscape* is a concept created by Michael Lancaster in the book with the same [4]. Lancaster proposes this term to designate the phenomenological reading of the urban space and how the colour of a building is contextualized in its environment. This concept, derived from Landscape and Townscape, reveals a way to learn to understand the hierarchies and qualities of urban space through colour perception.

f) *Geography of Colour* is a concept created by Jean-Philippe Lenclos [5], arguing that we can consider a certain colour palette as characteristic to a specific place. The colours of the natural environment (stones, wood, vegetation, etc.) and the colours of the artificial environment created by man (buildings, streets, etc.) being the result of a specific interaction and coexistence between man and nature, determine this palette, which distinguishes races and cultures. He also refers the importance of the distinction between permanent colours (stones, painted surfaces, etc.) and non-permanent colours (sky, vegetation, etc.).

g) *Colour Loci* (*Colore Loci*) is a concept created by Claudia Raimondo [6], derived from *Genius Loci*, a fundamental definition created by Norberg-Schulz [7] to reveal the unique phenomenological characteristics of any site: *the basic act of architecture is to recognize the “vocation” of a place*. Raimondo applied this concept in Restoration argueing that these values should be preserved in any architectural or urban intervention.

h) *Emotional Atmosphere* is a concept derived from the phenomenological approach of Peter Zumthor defining atmosphere as an instinctive and emotional perception [8]. Carla Lobo and João Pernão used this notion to describe colour as a sensation, *a synaesthetic feeling that communicates an immediate emotion, an emotional atmosphere* [9]. As we walk through our city, colour has a prominent role in the process involving the transmission of sensorial information from our environment to our brain, and consequently in the immediate emotional atmosphere.

i) *Light* is the condition for visibility and therefore should play a determinant role in a colour survey. The importance of day/night differences in urban perception, suggests the necessity to include this concern in strategies of urban planning, for a better unity, permanence and significance of the city in its inhabitant's and visitor's memory [10].

j) *Time,* a fundamental variable to architectural perception, is, according to Bruno Zevi, its fourth dimension [11]. This variable is responsible for the light and colour perceptual change over a day and over different seasons of the year as well as the changes derived from our movement through space. The chromatic atmosphere of a space is always a diachronic impression.

We believe that this insight into the practice of architectural colour survey will raise relevant information from the object of study and therefore be very useful in supporting the main decisions at later stages of the colour plan. This input could be the difference between a strictly technically driven colour study and a more human and sensory driven one, which could better understand the specific characteristics of each place and its relations with the inhabitant's or the visitor's experience.

To illustrate these premises we present some results of practice both as Colour Consultant and as teacher and researcher at the Faculty of Architecture, University of Lisbon.

References

[1] Cullen, G. (1983). *Paisagem Urbana*. Lisboa: Edições 70.

[2] Lynch, K. (1982). *A Imagem da Cidade*. Lisboa: Edições 70

[3] Pallasmaa, J.(2005).*The Eyes of the Skin*: Architecture and the Senses. Chichester, UK: John Wiley and Sons, Ltd.

[4] Lancaster, M. (1996) *Colourscape*, Academy Editions, London

[5] Lenclos, J.P. & Lenclos, D. (1999). *Couleurs de L'Europe: Geographie de La Couleur*. Paris: Editions Le Moniteur.

[6] Raimondo, Claudia (1987). *I Piani de Colore: Manuale per la Regolamentazione Cromatica Ambientale*. Maggioli Editore

[7] Norberg-Schulz, C. (1979) *Genius Loci: Towards a Phenomenology of Architecture*. Rizzoli

[8] Zumthor, P (2006) *Atmosferas*, 1st Ed. Barcelona: Editorial Gustavo Gili,

[9] Lobo, C. & Pernão, J. (2010) *Glazed Tiles as an Improving Element for Environmental Quality in Urban Landscape*. Colour: Design & Creativity (5) (2010): 9, 1–12 http://www.colour-journal.org/2010/5/9/

[10] Pernão, J. (2013). *Night and Day in Urban Landscape Perception*. Proceedings: AIC Colour 2013, 12th Congress of the International Colour Association, 8-12 July 2013, Newcastle-upon-Tyne, England.

[11] Zevi, B. (1977). *Saber Ver a Arquitectura*. Lisboa: Editora Arcádia.

Strategies in colour choice for architectural built environment

Pietro Zennaro
Università Iuav di Venezia, Venice, Italy

In the realization of a colour design, or of a colour plan, every designer should have availability of a set of basic tools to allow him to not perform prejudicial operations in the territory, in the landscape, in the city, in the neighbourhood, down to the individual building.

The same designer should then know some few rules in the colour choice that will enhance the built environment. Obviously the approach to colour selecting depends on the size of the buildings, the type of aggregation, the streets, alleys, plazas, squares dimensions and so on, but especially by the specificity of the place. With specificity of the place we mean the history, traditions, culture, geographical location, the qualities and weaknesses, the range of possible options and not recommended steps and all those characters that distinguish one place from another. So it should be clear to the designer who faces a chromatic project that primarily he need a dedicated strategy different from case to case, specific to each place.

The diversity of the places establishes the richness of traditions and customs that should be preserved and possibly updated. What's discussed in the paper is the result of research experience at the University Iuav of Venice and in the direction of the Research "Colour and Light in Architecture" Unit and professional work in the colour planning for villages/towns with an historical centre, expansion zones, sprawl, isolated houses or industrial areas. The focus on the improvement of the places through the appropriate use of colour is determined both by the need for upgrading the man-land, either by putting in place qualifying low-cost factors, highly valued in today's stagnant economy, like the Italian one.

The perception of the surroundings takes place in terms of synaesthesia, involving all the senses of the recipient. The colours possess various features that can zoom in or out the perceived objects, as well as enlarge or shrink them, make them hot or cold, centre or decentralize them. The colours are also responsible for many other phenomena that will be better explained in the full paper.

In the perception of the surroundings built forms are perceived differently depending on weather conditions, seasonal ones, direct or indirect radiation, by reflection or by natural or artificial light source and by many other aspects. The shape/colour ratio is also reflected by a series of secondary effects such as:

- Distance effect: far, from afar, close, very close;
- Spatial Effect: very large, large, medium, small, very small;
- Environmental effect: wet, dry;
- Light Effect: on, off, sunny, shady;
- Weight effect: light, heavy;
- Time Effect: short, medium, long;
- Thermal effect: cold, hot and lukewarm;
- Psychological effect: depressive, relaxing, soothing, stimulating, exciting, exhilarating.

These effects depend on the wavelengths and change on the basis of colour saturation. The feeling of space, in terms ponderable and temporal change with the wavelengths increase and varies according to the hue intensity. Other effects depend on the combination of closeness or distance and the overall design or perceived detail. Some basic rules for who intends to proceed with the selection of colours to paint the buildings walls and their parts has to make reference to the general guidelines to consider when treating for example:

- Narrow streets
- Wide Roads
- Squares, plazas, etc.
- Sprawl houses
- Farmhouses
- Buildings in barren, arid, stony field
- Continuous façades
- Tall buildings
- Public buildings
- Industrial buildings
- others

The list just described already constitutes a strategic approach in planning operations where the use of colour as a design element treated with extreme care and attention, trying to leave the least possible space to casual approach, although in some cases this has produced funny situations (e.g. Burano island). The full paper will better describe what synthetically here is mentioned.

Figure 1. Burano island. Casual colours combination generating funny situations.

Poster Session #3

Common basis for colour and light studies

Ulf Klarén[1], Karin Fridell Anter[2]
[1]Metkroken 4, 193 41 Sigtuna, Sweden
[2] Noreens väg 71, 752 63 Uppsala, Sweden

This paper discusses the need for a common basis for research, education and practice regarding colour and light in the spatial context. It starts from the human perspective on colour, light and perception and argues for new scientific and pedagogic approaches.

In traditional colour theory, with its origin in art and crafts, colour is often treated as something isolated and in its own right, sometimes with mystical overtones. Ultimately human perception works, however, with the aim of making the surrounding world complete, stable and apprehensible. Aesthetic experiences of colour are part of this multi-dimensional process of knowledge and should be viewed in this overall perspective. Interplaying with all other senses and cognitive abilities, seeing colour helps to continuously unveiling the world around. In this, an understanding of light is necessary.

Human experience of colour and light in the spatial context is both perceptual and cognitive. What we call adaptation is not limited to basic physiological reactions [1]; it is interplay between the individual and the world on many levels. The complex nature of human experiences has implications for the possibility of using traditional scientific research methods to describe and analyse experiences of colour and light. This does not, however, mean that systematic research on the coherent colour and light experiences would be impossible, but that it has certain important limitations.

Physical and psychophysical studies on colour and light have merely an indirect relation to human experience. Their contribution to description of colour and light is limited to causal relations. Direct experiences are coherent, dynamic and dependant on the surrounding world. They are made up of perceptual qualities and cannot be reduced or separated from their spatial and cultural context. Understanding of the interaction between colour and light demands a holistic approach, a qualitative or descriptive research methodology and an interdisciplinary approach including such fields as psychology, neurology and lighting technology. Although relevant research has long been carried out within all these fields, knowledge is, however, still fragmented and lacks coordination.

One possible common perspective to all fields of research on colour and light could be phenomenological and ecological; there are in the phenomenological tradition attempts such as David Katz' definitions of spatial modes of appearance of various colour and light phenomena [2] and James J. Gibson's ecological approach to visual perception [3]. The correspondence between Katz' phenomenology and Gibson's ecological perception indicates a possible way to a coherent ecologically based phenomenology describing colour and light as parts of a coherent human experience of the world.

Another possible common perspective – or common platform for research - could be found in aesthetic philosophy. Susanne Langer [4,5] claims that the emotional content we can experience in a piece of art or a designed object is symbolic in a special way: perceptual patterns of colour, light and form, abstracted from their normal context in life, are used as symbols for "felt life". The sources of such 'logical expressive symbols' are physical, perceptual, cognitive and cultural. The expressive symbols also form human experiences of the natural world around, as we continuously scan the world searching for significant form and meaningful perceptual patterns.

The manifoldness of human colour and light experiences cannot be quantified or mapped in detail. No specialised scientific area of research on visual perception or visual understanding is capable of giving a full description of the coherent visual experience. Genuinely interdisciplinary studies, with explicit ambitions to search common concepts and formulations, would gradually contribute to more well-founded and coherent descriptions of visual experience. It would also elucidate the relationship of each specialised area of research to the living visual experience of colour and light as a whole and thus open for new research questions in connection to this broader perspective. One attempt in this direction was the project SYN-TES – Human colour and light synthesis: towards a coherent field of knowledge. [6] There is the need for much more!

References

[1] Noë, Alva. 2004. Action in Perception. (Massachusetts: The MIT Press).

[2] Katz, David. 1911. The World of Colour. (London: Routledge, 1935)

[3] Gibson, James J. 1979. The Ecological Approach to Visual Perception. (Hillsdale, NJ: Lawrence Erlbaum.

[4] Langer, Susanne K.1957.Problems of Art: ten philosophical lectures. (New York: The Scribner library).

[5] Langer, Susanne K.1953. Feeling and Form. (London: Routledge & Keagan).

[6] SYN-TES – Human colour and light synthesis. Publications 2010-2013 available at www.konstfack.se/SYN-TES.

Colour constancy: balancing primaries in extremis

Loredana Minini[1], Thomas Bangert[2]
[1] Queen Mary University of London, England
[2] University of Oxford, England

Colour constancy is the ability of the visual system to compensate for inequalities in the light source that illuminates the objects of perception. This study investigates the nature of this compensatory system by pushing illuminant inequalities to an extreme. We presented subjects with a colourful environment illuminated at a level of brightness approaching that of indirect natural sunlight (approximately 4000 lux) but with individual levels of each of the primaries under arbitrary control. Subjects were presented with one or more of the constituent primaries systematically removed from the light illuminating the environment. To test colour constancy, subjects were presented with objects that under conditions of natural sunlight are perceived as either white or as a strongly saturated primary colour (red, green, blue and yellow). This forces the underlying system that is responsible for compensating for unequal illumination to balance each primary independently, allowing us to study how the visual system responds in respect of each individual primary. We tested this extreme imbalance both with respect to white balance and with respect to each primary colour.

White balancing was found to be by far the most pronounced in its response to illumination deprived of one or more of the primaries; even with a monochromatic illuminant subjects failed to notice the missing primaries and continued to perceive white objects as (more or less) white. Coloured objects (of the respective missing primary colour(s)) were, however, perceived as achromatic – indicating a zero value either from the sensor or the early visual system. A zero value cannot be balanced using simple low-level techniques such as multiplication. This indicates the intervention of higher level visual processing. Low-level compensatory mechanisms could therefore not be studied with respect to white balance. The perception of colour on the other hand does require some light from the respective primary; a blue object will appear black when all blue light is removed from the illuminant, and so too will a red or green object when the respective primary is removed. The threshold for colour constancy can therefore be determined by testing the level of the specific primary needed for the perception of the respective primary colour. When the illuminant was completely deprived of blue, the blue threshold (the amount of blue light needed by a subject to perceive objects as blue) was found to be approximately at the absolute limit for non-dark adapted vision; about 1% of the level of illuminant used, which is the dynamic range of the cone sensor neurons used by the human visual system (without access to any of the adaptation mechanisms to expand this range). When using blue as an illuminant, the threshold for green was very similar to blue. Sensitivity to red was on the other hand much greater when using the same illuminant, with only one quarter of the light levels of green needed for objects to appear red.

Much higher threshold values were found when red and green were contrasted with each other. Here the threshold was found not to be an absolute value at the sensor limit (within the range of adaptation) but a ratio of approximately 10% of the level of the illuminant. Below this threshold, subjects reported objects as “glistening” or “glittering” with reflected light (due to the intensity of illumination) but continued to report the colour of the object as “pure black” or as achromatic. In the case of red using a blue illuminant subjects reported perceiving red objects as brightly coloured with levels of reflected light at the absolute sensor threshold, yet if the illuminant was changed from blue to green the same red object reflecting the same level of red light would be perceived as black. For subjects to perceive the object as coloured the amount of red light had to be increased by a factor of

30, and even at these levels subjects reported the colour as muted or ‘dark’. For a red object, the amount of green and red light reflected at this threshold was about equal to the level of light reflected from a cinema screen were an image of the object projected onto it (approximately 100cd/m2). The perception of black must therefore be a choice of the visual system rather than simply a product of sensors failing to measure light levels. The very low threshold values found with respect to blue indicate that blue acts in effect as an independent primary, which can compensate over a wide range of blue light levels. Our findings indicate that a blue primary can also be removed without significantly affecting the perceptual appearance of objects of the remaining primary colours, but we found this was not true for the red and green primaries. Taken together, these findings suggest a lack of true independence in these primaries, and indicate evidence of complex low level processing.

References

[1] D'Zmura, & M., Lennie, P. (1986). Mechanisms of color constancy. *J. Opt. Soc. Am. A*, 3(10), 1662-1672.

[2] Kraft, J.M., & Brainard, D.H. (1999). Mechanisms of color constancy under nearly natural viewing. *Proceedings of the National Academy of Sciences*, 96(1), 307-312.

[3] MacAdam, D. (1985). *Color Measurement: theme and variations*. Springer.

[4] Van De Weijer, J., & Gevers, T., & Gijsenij, Arjan. (2007). Edge-based color constancy. *IEEE Transactions on Image Processing*, 16(9), 2207-2214.

[5] Wyszecki, G., & Stiles, W. (1967). *Color Science*. John Wiley.

Colours of designed nature

Henriette Jarild-Koblanck, Monica Moro
Studio Koblanck, Mörbylånga, Sweden

The research project is aimed at exploring colour and spatial experience in green urban spaces, specifically avenues. It is carried out in Sweden through the observation of an avenue, of its rhythmical change of shape and shifting of colours. The methodology applied is through photographs and reflections.

The experience of colour in nature over time can provide a link between the contemporary moment and history, not merely giving a different view of an environment and also a city, it can really and in many ways be of significance to our experience of life. The presence of nature in an urban space gives us not only the chance to be aware of the time passing but also provides us with a setting for our emotional moods.

The project was started by Henriette Jarild-Koblanck, a design and colour researcher, who attracted by an avenue about two kilometres long, quite near her home in the Swedish Öland island, located in the Baltic Sea, lined by tall elms, decided to collect pictures of it at different seasons and times of the day. The avenue is unique in its kind as she describes it with her own words *"to walk through it at different times during the day gives you different impressions. Early in the morning its green colour is light and easy, but late at night it becomes dark nearly black, a place full of secrets."*

The green foliage changes colour during the day and changes the perception of what we define *"room".* You can observe this happening also in a city, or a neighbourhood, the presence of trees as urban furniture designed to be placed in lines as decoration, become, growing, also pillars supporting green arches, and shape new spaces, almost an archetype or a precursor of colonnades. A further thought is that the experience late in the evening, when it is dark, could be conceptually related to a meeting between Adam and Eve.

In cultures around the world usually one or more divine figures created the first human beings either through a dream, a thought or a word, a dance if not a song, or by shaping some type of material. Adam and Eve, the two first humans, are in Norse mythology called Ask (Adam) and Embla (Eve) respectively male and female. The deities Odin and his brothers created them using the wood taken from two different trees, ash and elm. In fact, while Ask means the Ash tree, Embla is usually associated with the Elm tree. Thus the avenue could be an experience of a sacrificial site, a sacred place, which was often an open space surrounded by unique trees. Here again there is also, of course, the connection to the theatre, but more as an individual experience of a particular place and time.

As a further reflection, in analysing the living environment created by the trees, we may take in consideration Deleuze and Guattari's thoughts on the rhizomes, which allows us to move in completely new connections, space and time cease to exist in the real sense. A nice definition of the rhizome's horizontal movement going against *"chronology and organization"*, and preferring instead a random system of growth and spread is given by H. Mattsson and S O Wallenstein in their book on Deleuze. They consider this model as a space where culture spreads like water extending to all the available space, crumbling down everything that comes its way and running down to new areas through cracks and gaps. *"The surface can be broken and moved, but these disorders leave no trace, because the water is loaded with pressure and a constant potential to find its balance point and thus seek a level surface"*.

The concept runs out of what they call the *"smooth space"* that refers to an environment, a landscape in which a subject operates. Deleuze and Guattari described it as follows: *"It is a space of affects, more than one of properties. It is haptic rather than optical perception (…) It is an intensive rather than extensive space (…) Conducive to rhizomatic growth and nomadic movement, smooth space consists of disorganized matter and tends to provoke a sensual or tactical response rather than a starkly rational method of operation or a planned trajectory."*

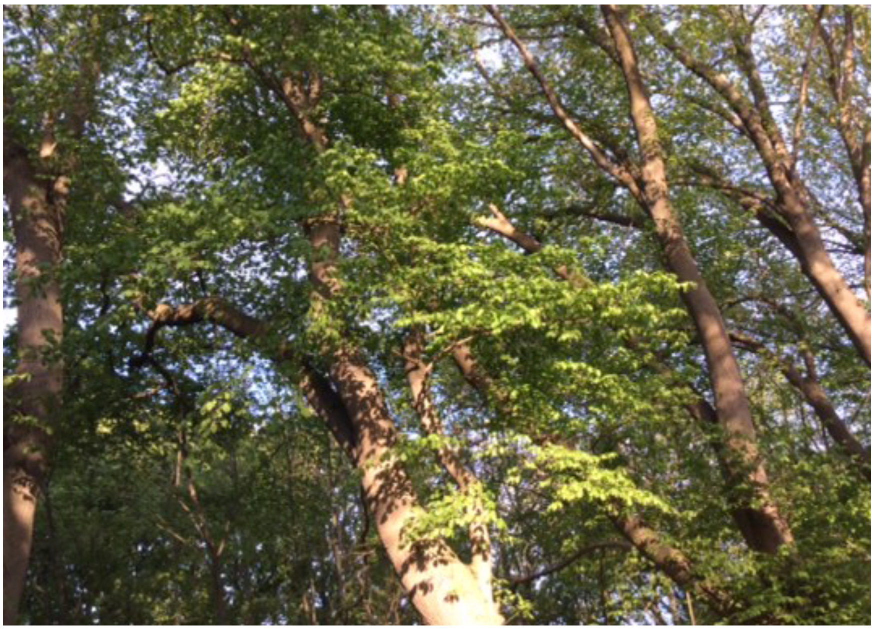

Figure 1. Image of the alley located in the Swedish island Öland

References

[1] Mattsson, E, Wallenstein, SO, (2010). Gilles Deleuze och mångfaldens veck*,* 254 pages.

[2] Summerson, J, (1980). The Classical Language of Architecture*,* 144 pages.

[3] Evers, B, (2002). Architectural Theory: From the Renaissance to the Present 89 Essays on 117 Treatises*,* 845 pages.

[4] Thorpe, B, (2010). The Elder Edda of Saemund Sigfusson*,* 390 pages.

[5] Stookey, LL, (2004). Thematic Guide to World Mythology*,* 265 pages.

[6] Deleuze, G, Guattari, F, (2013). A Thousand Plateaus*,* 744 pages.

Local colour identities: a literature review of urban environmental colour

Johnny Jie Xu
Loughborough University, Loughborough, UK

This paper is part of literature review in my first year PhD report, entitled Colour Identity in Urban Environment. The experience of colour identity in urban environment depends on different local circumstances. Local colour is an important part in defining cultural identities of a place. Thus the study intends to provide an insight of the relationship between colour and local identities in different scale of urban setting. The researcher considers the factors that the meaning of colour identities involves the knowledge of local culture, sociology, psychology and geography. The multidisciplinary approach to literature will provide dynamic perspectives to determine the significance of colour identity in different scale of urban setting.

In particular, the literature first considers the local identities as collective memory and reviews the concepts of 'Local colour' (Green-Armytage, in Zybaszynski, 2014), 'Geography of colours' (Lenclos and Lenclos, 2004), 'Place of memory' (Nora, 2000), and 'Causal true-maker' (Le Poidevin, 2007). Secondly, from the idea of 'Sense of belonging' (Barthes in Jenkins, 1996), two main theories from psychological aspects are discussed: Maslow's (1943) hierarchy of needs and Holmes' (1993) 'Attachment' theory. Thirdly, central to the definition of identity, the literature shows a set of opposite perspectives to study the colour identity: 'Internal and External Identity' (Jenkins, 1996), 'Self-image and Public –image' (Hall, 1990), 'Insideness and Outsideness' (Relph, 1976), and 'Insider and Outsider' (Zukin, 1995). Lastly, the research engages in the argument of globalisation and locality related to urban environment, such as the idea of 'Single place' or 'Same place' (Robertson, 2005) and the argument of 'Homogeneity and Heterogeneity' (Bernard, 2005). And the literature introduces a new thinking of 'Global network' (Castells, 2004) for the viewpoint of local identity.

The paper finds out that local colour identities, defined by geographic and temporal dimensions, have become a part of historical civilisation. The collective colour memory of a city has been registered as the heritage of local or regional culture. Certain unique colours can be seen as identities, which help to form the identification of characteristic elements specific to a local environment. Colours as an attachment to particular cultural group provide a sense of belonging. An acceptable colour identity must be an integral part of self-image and public image. The internal and external processes interact and exchange the norms of identification. The cognitive complexity is determined by both of insiders and outsiders. The local colour identity can be understood as potential sources of resistance to the homogenising effects of globalisation. Not only local colour identities should be seen from a micro local scale, but it also should be looked extensively from the global network in a macro scale.

Color determined by taste of the middle class and its influence on the aesthetic image of the city and buildings in the nineteenth and twentieth centuries

Agnieszka Rek-Lipczyńska, Izabela Kozłowska
Department of History and Theory of Architecture, Faculty of Civil Engineering and Architecture, West Pomeranian University of Technology, Szczecin, Poland

In modern methods of interpretation the city is portrayed as an environment created by many components of a specific activity, as well as a defined set of human activities and the set of places, which are equally physical space and mental space. The physicality of space, determined by parameters such as geography and time, is complemented by the social aspects and becoming of the material-social construct according David Harvey. So, looking at the urban space as an alive structure, we can see an image of the networks, which are in mutual connection and relationship between of the physical, mental and social spaces, resulting from the shaped social structure. The middle class, separated in the transformation process of the industrial revolution in the 19th c., was and still is a strong opinion-forming environment, which has a significant influence on the culture and the aesthetic appeal of urban spaces.

Social class division which was formed and perpetuated for centuries in the culture through distinct experience of individual social classes, equiping each communities in separate sensory, which had the influence on shaping of the taste. Among the urban components shaped by the taste of the middle class we couldn't ignore the phenomenon of the color and its impact on the perception of space and form, or the impact on the psyche of the recipient. Piotr Setkowicz wrote in his article „Barwa – bagatelizowany wymiar środowiska mieszkaniowego / Colour - underappreciated dimension of the housing environment", that color was one of the important factors of integrated social order, spatial and ecological in the living environment of man.

In the 19th c. the juxtaposing of the colors, that used in the composition of architectural and interior design, underwent changing fashions. At the beginning of the 19th c. in the projects of the interior middle class houses were used juxtaposing of the colors that were based on a clear contrast between the bright colors such as pinks, purples and browns in pale tones and strong shades of the complementary colors. Juxtaposing shades of purple with intense green or shades of tawny yellows with shades of plum purples were widely used and accepted as pleasing to the eye. While white color was not practically applied in architectural projects before the middle of the 19th c. and was associated with a bad taste. Published in England in 1810 by J. W. Goethe „Farbenlehre" theoretically has consolidated intuitively so far composed color sets. In his work Goethe presented a study of the natural order of colors and presented the theory that each natural color was assigned to the complementary color. This theory enabled the creation of harmonious color combinations, which was based on a scientific basis. Goethe's theory was popularized in England by D. Hay in his „The Laws of Harmonious Colouring adapted to House Painting". Hay argued for creation of the harmony color by creating combinations based on the juxtaposing between complementary and neutral colors.

On the one hand, there is the common opinion that the colors of the nineteenth-century frontage are quite uniform. On the other hand, overloaded stylistically and aesthetically with vibrant colors taste of the middle class was criticismed in 1851 by J. Ruskin. His comments are contrary to the general opinion about the supposed monotony of urban landscape and architecture in the 19th c. The opinion, that the colorful colors, which were painted houses during the history of creation of architecture in the 19th c., seems to be true, because the color palette used in this century was much richer. Too colorful sets at the facades of the buildings was be able to wake the true “disgust” on the part of authorities like Ruskin, however, it does not mean, that this colorful sets was completely abandoned in favor of the precious white and gray colors. Keep in the mind that the 19th c. is the triumph of the industrialization, mass production, new technology of chemical dyes and their dissemination. The chemical colors of the century of industrialization were willingly used by the middle class and were associated with the collapse of the aesthetic. The intense colors reserved only for the wealthy and associated it with the luxury or the vanguard in the 19th c. were become universally available for the middle class have become synonymous with moral decay.

The emergence of modernist architecture, with its aesthetic and ascetic discipline of the color, collided with a lack of understanding and rejection by the middle class of its value. The flagship product of the modernism offered the middle class has become a prefabricated housing architecture that has dominated the image of the city throughout the 20th c. The anonymity of the modern urban space particularly is observing in the countries of central Europe, including Poland, combined with aesthetic monotony leads to disorders of the identity of its inhabitants. Attempts to break the monotony of aesthetics settlements do not bring the desired results, and even led to the crystallization of the unrestricted style which is testament to bad taste. Today the surfaces of the facade blocks, raw in the original plan, are using as a great painting canvas and coloring with fantastic visions. Color is used with almost childlike naivety and covers large areas of buildings. Ironically, "pure" style of the modern facade is evolved into fairground performances of juggling all the colors of the rainbow.

Acute need to escape from the depressing monostructur pushed residents toward the expression of extreme emotional states and attemption to give of new values of the modern residential environment. In search of a better quality of the buildings, color is used as an emotional support, distraction from the dullness and monotony of forms. Because of the missing diversity the modern buildings is painting for the comfort of the residents but to the “horror” the architectural environments.

Communication chaos and "screaming color" of our cities are, therefore, an expression the taste of the middle class, which as never before in history, has a significant impact on the surrounding urban space.

The effects of correlated colour temperature on wayfinding: a study in a virtual airport environment

Özge Kumoğlu, Nilgün Olguntürk
Department of Interior Architecture and Environmental Design, Bilkent University, Ankara, Turkey

Wayfinding is a spatial problem solving activity comprising the following interrelated processes; decision making, decision executing and, information processing [1]. In the literature the effects of lighting on visual performance and environmental perception are widely found to be significant. In addition, information processing is one of the three following processes of wayfinding in which environmental perception and spatial cognition interact. The major aim of the current research is to examine the effects of lighting correlated colour temperature (CCT) on the wayfinding performance of travellers in airports. Another purpose of this study is examining sex differences in wayfinding performance, since previous studies found that males and females react differently to colour and light [2, 3, and 4].

Before the experiment, 15 volunteer tourists and four airport staff were chosen randomly for an unstructured interview in Esenboğa airport. The aim was to understand whether travellers find their way easily or not and how they find it. The density of the circulation area, tourists' profiles, the colour scheme, spatial organization and lighting quality were all examined in order to prepare a generic airport in a virtual environment and select a route for the experiment. Providing an appropriate route representing a real travelling experience was important. According to the knowledge gained from airport staff, people usually asked questions as soon as they entered the airport about how to get to their assigned gates. Therefore, the researchers decided to use a route that started at an entrance and ended at a specified gate (see Fig. 1.).

There are three different experiment settings, but the difference between them is in the lighting CCT only. The RGB values of colours are used in interior spaces, and illuminance level and space organization are kept constant for all the experiment settings. The illuminance level recommended for circulation areas in airports is identified as 200lx, however there are no recommendations identified for CCT of lighting in airports [5]. This study compares three different CCTs (warm-white; 3000K, cool-white; 6500K, and bluish-white; 12000K) to explore the effects of CCT of lighting on wayfinding performance of travellers in a virtual airport environment.

The participant group consisted of 90 graduate and undergraduate students from 21 departments of 26 universities across central Anatolia in order to provide a variety. There were 45 females and 45 males, ranging in age from 19 to 45 (m=24.84, std. dev. =3.66, n=90). The experiment was conducted in a single phase with three different sample groups in three different lighting settings: 3000K, 6500K and 12000K. Participants experienced a desktop virtual environment one by one. A single LED LCD screen of 10.1'' was used in the study. The screen was calibrated as follows: gamma: 1.0, brightness: 0, contrast: 50. The screen resolution was 1024x600 and the colour quality was 32Bit. Participants were asked to direct the researcher from the starting point to the final destination. Every six meters, the images were changed by the researcher according to the verbal direction of the participant until finding the destination. Meanwhile, the directions, time spent, errors, route choices and hesitations of each participant were noted. The participants listened to the background noise of an airport to feel sense of presence.

It was found that CCT has no significant effect on wayfinding performance in terms of time spent, total number of errors, total number of decision points or route choice. However, CCT does have a significant effect on hesitation; the number of hesitations decreased when CCT increased from 3000K to 12000K. Sex difference was also explored regarding hesitations in this study. The findings of this experiment may provide some clues not only for interior architects but also for environmental psychologists who may be interested in different factors affecting user behaviour. Additionally, airport managers can benefit from the results of this study which explains the effect of CCT of lighting on wayfinding performance of travellers in an airport circulation area. The suggestion originated from this research is the fact that yellowish-white lighting (3000K) CCT causes lack of confidence in wayfinding behaviour, increased hesitations and number of errors of travellers and therefore should not be used in the circulation areas of airport lighting.

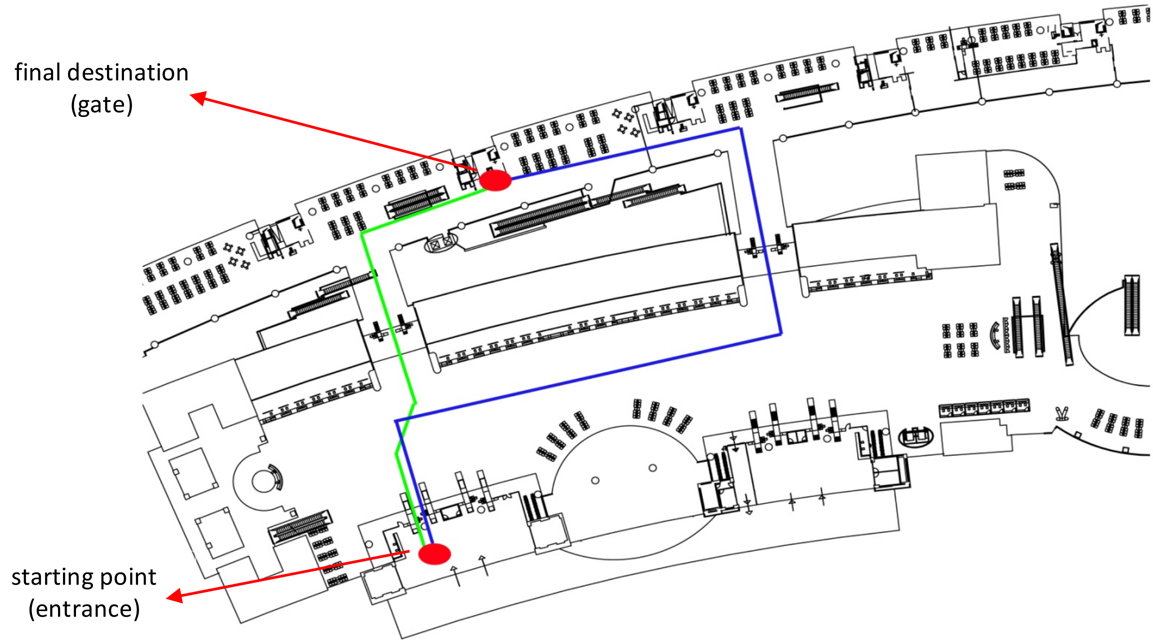

Figure 1. Partial plan of the airport building showing the selected routes (green line: short route, blue line: long route)

References

[1] Arthur, P. & Passini, R. (1992). *Wayfinding : People, signs, and architecture*. Toronto: McGraw-Hill.

[2] Knez, I., & Kers, C. (2000). Effects of indoor lighting, gender, and age on mood and cognitive performance. *Environment and Behavior, 6,* 817–831.

[3] Knez, I. (2001). Effects of color of light on nonvisual psychological processes. *Journal of Environmental Psychology, 21*, 201-208.

[4] Yıldırım, K., Akalın-Başkaya, A., & Hidayetoğlu, M. L. (2007). Effects of indoor color on mood and cognitive performance. *Building and Environment*, *42,* 3233–3240.

[5] Illuminating Engineering Society of North America (2000). *The IESNA lighting handbook :Reference & Application.* Illuminating Engineering Society of North America.

OSCC Open-source colour collection for Polish interiors

Agata Kwiatkowska-Lubańska
Faculty of Industrial Design
Academy of Fine Arts, Krakow, Poland

Open Source Colour Collection is a set of 100 colours designed for the use in residential interiors in Poland. It is based on my years of experience in working for paint manufacturers and collaboration with interior architects. The presentation concerns the issue of using colour in contemporary Polish interiors. Colours in interiors, in a particular country, are connected with such factors as local tradition, materials and dyes, as well as colour preferences of its residents which reflect the surrounding flora, climate and landscape, as well as colour symbolism, and various aspects of material culture. Poland, as a reason of its historical conditions, is not a country where a lot of attention is paid to the colour. Most of Polish people rarely seek the advice of interior architects, instead preferring to make their own choices concerning interior arrangement. Economic problems, which we experienced during 45 years of communist regime, have caused many people, especially the older ones, to have problems concerning the choice of colour for their homes. The example of Polish companies shows that extensive colour charts derived from a standard colour notation system (Pantone, RAL, Munsell, ACC) are solutions rather for designers and architects than for an average consumer. A collection of ready-mixed colours with a limited number of paints makes it easier for the customers to choose the colour. Sadly, the Polish companies very often commit plagiarism, copying the colours from the ready-made collections of their competition. Paint colours are not protected by law. Around 40 colours are repeatedly introduced under different names, making Polish interiors too similar and public spaces not up to modern standards.

The idea for the **Open Source Colour Collection** comes from the fact, that promoting beautiful colours in our environment should not depend on the strategy of the manufacturers, but constitute a public interest. OSCC, available on the website of Polish Colour Association, allows the viewer freely decide on the choice of paint without being tied to a specific brand. Each one of the colours was tested in interiors, used in colour combinations and dedicated to a certain style of interior decoration. They all have the NCS reference because the Natural Colour System is the most popular colour system in Poland and the colours can be obtained from the most of commercial paint mixers.

Sustainable colour design in architecture: materials, technologies and products

Alessandro Premier[1], Katia Gasparini [2]
[1] University of Udine, Udine, Italy
[2] IUAV University of Venice, Venice, Italy

When we should consider the colour of a building a sustainable feature? In the contemporary architecture old and new materials, technologies and products are complying to the new rules of sustainability by providing the architectural project the means to adapt to the new challenges of contemporary innovation. Of course colour seems to play a strategic role in this scenario, adapting to the choices of the different points of view – sometimes ideological - of contemporary architecture.

In most of the researches that are focused on the environmental sustainability of buildings, colour is often overshadowed. However as we well know, colour plays a strategic role not only from an expressive point of view, but also in the control of the internal and external environmental quality of buildings and also for their indoor climate. Indeed, we can think about the colour of the surfaces of the building as a tool for the integration with landscape or as a tool for controlling the heating of the surfaces irradiated by the sunlight. This research tried to go further.

We decided to consider the entire life cycle of twelve large families of materials, technologies and products, without neglecting some lessons from the past. To assess the sustainability of a material, a technology or a product we must be aware of the period in which it fails to provide the maximum of its performance and their decay all over the years. In this sense the colour fastness can be an indicator of the health status of the material. When we deal with colour, however, this aspect cannot be separated from broader evaluations that frame the colour of architectural surfaces in a relationship of harmony or contrast [1] with the surrounding environment. Basically it means we consider colour as a design tool to achieve certain effects that influence the perception of the building in its context. Perhaps the colour of architectural surfaces will be more “sustainable” when it will succeed in time to keep or positively change the relationships with the environment so that the initial project idea will keep its full effectiveness.

Considering this last idea, the paper wants to sum up the results of a recent research conducted among the “Eterotopie” Research Centre by the author with the precious contribution of V. Brustolon, A. Dehò, C. Gregoris, A. Martini, P. Zennaro and K. Gasparini [2]. The researchers, dealing with various specialisms, studied the chromatic use in the architectural design of 12 families of materials, technologies and products with the aim to assess their real impact on the environment and the possible solutions based on a scientific and rational approach. For this reason, a specific methodology of research aimed to scan the entire life cycle of the colours of the architectural materials and products (LCA) has been chosen [3]. The paper and the poster summarize these specific contributions with the aim of providing a descriptive overview of the state of the art and the possible future evolutions.

Figure 1. Details of the sprayed concrete Klein-Blue coloured façade of Forum 2004 in Barcelona by Herzog & de Meuron. Photo © Katia Gasparini

References

[1] Itten, J. (1970). *The Art of Color: The Subjective Experience and Objective Rationale of Color*, Van Nostrand Reinhold, New York, p. 33

[2] Premier, A. (2014). *Innovazione sostenibile per l'architettura: materiali, tecnologie e prodotti*, Maggioli, Rimini, p. 11

[3] Ochsendorf, J. (2011). *Methods, Impacts, and Opportunities in the Concrete Building Life Cycle*, Massachusetts Institute of Technology Concrete Sustainability Hub, Cambridge, MA

What colour is the sacred?

Ken Devine
University of Portsmouth, UK

As an artist and academic, currently based in the University of Portsmouth, I have over many years been involved with participatory arts projects that engage with and encourage the audiences to become contributors both in the creation and the experience of the artworks. This method of working began in 1998 in an artist residency in a Junior School that asked the simple question: What colours are significant for you and why? As you can imagine the responses have been wide-ranging, often intriguing and at times deeply poignant. Since its inception this project now finally called 1001 Haphazard Colours, has been presented in various forms at approximately 30 public venues and has over 1000+ contributions. One of the reasons often given, directly or indirectly, as a significance characteristic/meaning of a colour is that of having a spiritual dimension and this is a theme I am pursuing in a new work by asking the simple question: What colour is the sacred? The responses to this ostensibly simple question will, I am sure, tend towards thoughtful consideration and rich interpretation. I am therefore proposing a project to build a new contributory artwork that pursues this question at a number of locations starting in the UK. The initial pilot will begin in Portsmouth Anglican Cathedral in March 2016 and will be running into 2017 and hopefully be moving to others throughout the UK.

Cathedrals are the obvious starting point for the project but I envisage it expanding out into the secular/humanist sphere as well as the overtly religious. In 2016-2017 Portsmouth Cathedral will be working on a new theme Faiths Connected where they will be exploring how Christianity and others faiths relate and how they can learn from each other. The project will intersect with this and will provide opportunity for multi-faith dimension to the new work. The work will be a video based digital installation and my goal is to build a visual ethnography of spirituality/the sacred embodied and symbolised though the medium of colours. As well as collecting digital video interviews I will be collecting an amount of metadata relating to lifestyle issues. The question of ethnography is where I am out of my depth and am therefore proposing that the project be situated academically in an Anthropology/Ethnography environment as an artist residency. My principle concern is, of course, the creation of an artwork but the information gathered through the collection of narratives and metadata would seem to open itself to a multi-disciplinary approach. The title: 'What Colour is the Sacred?' is taken from a book by anthropologist Michael Taussig.

As introduction to my previous work and to give some notion of the visual, see links below. These are not works that tackled the question of spirituality but are a starting point for the new project.

1001 Haphazard Colours is based on the identification of a colour that has specific meaning and association. Therefore it opens the door of perception through memory and symbolism and seeks inclusivity of age, gender and ethnicity. The sequence of stories played during installation is chosen by a random algorithm from a 3D virtual environment. The artwork makes an excellent basis for storytelling workshops. The software is highly adaptable and particular collections/archives of stories that represent a specific location can easily be created. See https://vimeo.com/113837177

The Haphazard Colour Machine is a meditative work that is ideally presented as a digital real-time rendered floor projection onto a surface of finely ground glass particles surrounded by charcoal. Colour is materialised. The floor becomes a glistening portal to an alternative environment of colour. The 'camera' wanders randomly through the environment never repeating itself. The purpose of this work is to engender an atmosphere of contemplation. See https://vimeo.com/113837585

Taste in 3 Colours is one of a series of works made from contributions that each thematically describes a metaphysical spectrum of embodied associations relating to the senses. See https://vimeo.com/98911938.

The work generally is part of a research degree [ArtD] that I am currently undertaking at the University of Middlesex. The title is: Social Spectrum, a study of rational, empirical and metaphysical relationships with colour.