THE COLOUR GROUP VISION MEETING

10:00-17.30. Wednesday 6th January 2010
Lecture Room, Institute of Ophthalmology

9:30 *COFFEE & REGISTRATION*

10.00 **Categorical perception and thresholds for colour discrimination across languages - what role does language play?**
Debi Roberson *University of Essex*

10.30 **Creating greyscale versions of coloured images: human and machine**
Marina Bloj, *University of Bradford*

11.00 **Palmer Lecture 2010: Are there phenomenal complementaries?**
Donald McLeod, *UC San Diego*

12.00 **Colour and orientation integrate in processing bimodal stimuli**
Galina Paramei, *Liverpool Hope*

12.30 *LUNCH*

13.30 **Cambridge Research Systems Sponsored Lecture 2010: Telling colours apart**
John Mollon, University of Cambridge

14.30 **Colour appearance in a changing world**
Hannah Smithson, *University of Durham*

15.00 **Quantitative assessment of commercial filter 'aids' for red-green colour defectives**
Jack Moreland, *University of Keele*

15.30 *GRANVILLE TEA*

16.00 **Neural coding mechanisms in color vision and the influences of natural scene statistics and context**
Thomas Wachtler, *LMU Munich*

16.30 **Effects of light spectrum on the colours of art paintings**
Sergio Nascimento *University of Braga, Portugal*

17.00 **Estimation of Individual Cone Sensitivities based on Colour Matching Functions**
Graham Finlayson, *University of East Anglia*

REGISTRATION. The fee including lunch is £16 for Colour Group members, and £20 for non-members. The fee without lunch is £7 for members and £10 for non-members. Cheques made to The Colour Group (GB). Send the registration form and cheque to Alex Halliwell, School of Psychology, Eleanore Rathbone Building, Bedford Street South, Liverpool, L69 7ZA so that it arrives by January 4th. For further information see the Colour Group Webpage or contact s.m.wuerger@liverpool.ac.uk.

ABSTRACTS

Categorical perception and thresholds for colour discrimination across languages - what role does language play?

Debi Roberson & J. Richard Hanley,
University of Essex.

Does the 'striped' appearance of the rainbow result from our habitual categorization of color appearance, or is it built into our perceptual systems? Categorical Perception (CP) of colours is said to occur when a continuum of equally spaced physical changes is perceived as unequally spaced as a function of category membership. CP might arise because perception is qualitatively distorted when we first learn to categorize a dimension. We review recent evidence that CP is abolished when participants undertake a secondary verbal task and is found selectively for stimuli presented to the right visual field (Roberson & Davidoff, 2000; Gilbert et al., 2006; Winawer et al., 2007; Roberson, Pak & Hanley, 2008). English speakers also show no evidence of superior discrimination thresholds at the boundaries between blue and green categories even though they display categorical perception at these boundaries in a supra-threshold task. Furthermore, there is no evidence of different discrimination thresholds between individuals from two language groups (English and Korean) who use different color terminology in the blue-green region. (Roberson, Hanley & Pak, 2009). We suggest that, at least for the domain of color, categorical perception appears to be a categorical, but not a perceptual phenomenon and describe a system of processing that might account for it.

Creating greyscale versions of coloured images: human and machine

Marina Bloj, Bradford Optometry Colour and Lighting Lab, School of Life Sciences, University of Bradford

Each year millions of greyscale reproductions of colour images are made.
The majority of these are produced by removing the chromatic information, which leaves a greyscale made by just the achromatic colour variable. One problem with this approach is how to make greyscales for images that contain equilumiant edges and/or borders in a way that preserves the image content. Routinely artists make greyscale images of colour scenes when working with charcoal and other non-coloured methods.

In my talk I will describe results from a novel experimental procedure were participants where able to create their own greyscale versions of coloured images. The process allowed us to study the effect of image content on grey settings. Special mention will made to the problem of which grey level is assigned to colours of equal brightness and saturation. I will also discuss other experiments where we evaluated some of the more recent algorithmic attempts to tackle the colour-to-greyscale problem. In this case we compared the performance of these methods against greyscale images created manually by human observers by using image preference experiments. Our results support the motivation for this research area: there are better ways to convert colour to greyscale than simply using luminance and that images created by human observers are comparable to those produced by algorithms.

This work has been done in collaboration with Graham Finalyson and David Connah from the School of Computing Sciences, University of East Anglia (UEA) and supported by joint EPSRC grants number EP/E012248 and EP/E12159.

Are there phenomenal complementaries?

Donald MacLeod Psychology Department, UC San Diego
Pamela Pallett Psychology Department, UC San Diego
Erin Krizay Psychology Department, UC San Diego

Color charts can capture some aspects of the phenomenal structure of color experience in a coordinate system with two bipolar axes, one for redness (positive) vs. greenness (negative) and the other for yellowness vs blueness. This leads to an arrangement in which perceptually unitary ('unique') red and green are found in opposite directions from white at the origin, and blue and yellow are similarly opposite, while the blue/yellow and red/green directions are mutually orthogonal. The neural representation of color by color-opponent signals is often viewed as supportive of such schemes. But the pervasive rectifying nonlinearity of neural responses, and the marked asymmetry between excitatory and inhibitor response dictated by the relatively low spontaneous firing rate, are more suggestive of an idealization with multiple monopolar signals for redness, greenness, yellowness and blueness. Wuth mutually orthogonal monopolar coordinates for the four primary signals, the isoluminant colors occupy the surface of a hypercube in the 4D space; white is at one corner. To test this scheme experimentally, subjects first identified examples of unique red, green, yellow, and blue perceived as equidistant from white. We then asked whether these colors are perceptually equidistant from each other, as the hypercube model predicts. One of the set of colors judged equidistant from white, for instance the red, was presented with adjustable purity, and subjects adjusted the purity as needed to make it as different from the green as from the blue or the yellow. On the hypercube model, no adjustment should be needed. But if there were perceptual red/green opponency, one would expect subjects to select a less saturated red than the one chosen in the first phase of the experiment. Results are close to the predictions of the hypercube surface model, with significant but small deviations.

Colour and orientation integrate in processing bimodal stimuli

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[3]Moscow State University, Russia

How do two distinct stimulus attributes, colour and orientation, interact as contributions to global dissimilarity? Line stimuli (N=30) that varied in hue (four cardinal colours, plus white) and orientation (six angles at intervals of 30°) were presented pair-wise to five subjects who judged their global dissimilarity. An exploratory analysis with multidimensional scaling showed that a minimal representation of the data required two dimensions to accommodate the circular sequence of the angular attribute, and two more, colour-opponent dimensions for the hue attribute. A 5th 'desaturation' dimension improved the fit by accommodating the qualitative gap between white and chromatic stimuli. We tested spatial models that used city-block, Euclidean and Dominance

metrics to combine the colour and orientation parameters. For these complex stimuli, spatial solutions with Minkowski coefficients >2 were found to provide best fit, thus indicating that colour and orientation modalities behave as integral rather than separable features. Overall, colour dominated orientation marginally, but the relative weights varied among subjects in a reproducible way. We discuss a synergistic relationship between the low-level vision attributes of colour and orientation, involved in image segmentation.

Telling colours apart

J. D. Mollon

What determines whether a normal observer will be able to discriminate two stimuli of different chromaticity? An ultimate limit must be set by the differences (or ratios) of the triplets of cone absorptions produced by the two discriminanda. Tyndall's Paradox, however, is one of several phenomena that reveal post-receptoral limits to discrimination: if wavelength discrimination is measured in the region of 450 nm and if white light is now added to both sides of the field, discrimination is found to be optimum when the discriminanda are of only 15% purity.

In recent experiments, Marina Danilova and I have found a region of enhanced discrimination in the region of the caerulean line (the locus of mixtures of skylight and sunlight). To choose our stimuli, we rescaled the vertical axis of the MacLeod-Boynton diagram so that a line passing through 576 nm and the metamer of Illuminant D65 had a slope of -45 deg. We then selected a series of lines that intersected this line at 90 deg, and we measured discrimination along these lines. The discriminanda were independently jittered in luminance to ensure that discrimination was based on chromaticity. Thresholds were expressed in terms of the factor by which L/(L+M) was changed. Discrimination was optimal near the caerulean line, and thus near the equilibrium hue where independent measurements showed a transition from reddish to greenish.

Colour appearance in a changing world

Hannah Smithson & Rob Lee
Department of Psychology, Durham University, UK

Our judgements of colour appearance depend upon the spatial and temporal context in which a test sample is presented. Yet, processes of perceptual constancy operate to maintain the almost constant appearance of objects despite changes in the conditions of observing. By manipulating (a) the history of chromaticities at a test location (temporal context) and (b) the chromatic composition of the surrounding area (spatial context) we investigate the mechanisms that determine colour appearance in a changing world. By measuring the migration of colour appearance boundaries after a change in chromatic context, we find that observers maintain a perceptual record over a duration of approximately 10-15 seconds, and that this can be modulated by spatial context. The ability to keep track of changes in chromatic context is important in a world with multiple illuminants and distinct sub-populations of reflectances.

Quantitative assessment of commercial filter 'aids' for red-green colour defectives

Moreland JD[1], Westland S[2], Cheung V[2] and Dain SJ[3].

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Claims made for 43 commercial filter 'aids', to improve the colour discrimination of red-green colour defectives, are assessed for protanomaly and deuteranomaly by changes in colour spacing of standard traffic signals (EN 1836:2005) and of the Farnsworth-Munsell D15 test. 'Aid' spectral transmittances are measured and tristimulus values with and without 'aids' are computed using cone fundamentals (De Marco, Pokorny and Smith, 1992, J Optical Society of America A, 9, 1465-76) and the spectral power distributions of either the D15 chips illuminated by CIE Illuminant C or of traffic signals. Chromaticities are presented in an analogue of a cone excitation diagram (MacLeod and Boynton, 1979, J Optical Society of America, 69, 1183-6) in terms of the relative excitation of long (L), medium (M) and short (S) wavelength-sensitive cones. After correcting for non-uniform colour spacing in the diagrams for protanomaly and deuteranomaly, standard deviations, parallel to the L/(L+M) axis are computed and enhancement factors E are derived as the ratio of 'aided' to 'unaided' standard deviations. Values of E for traffic signals with most 'aids' are < 1 and some of those (16 for protanomals and 11 for deuteranomals) are below the EN safety threshold of 8% luminous transmittance. A few 'aids' have expansive E factors but even the largest are quite small

Neural coding mechanisms in color vision and the influences of natural scene statistics and context

Thomas Wachtler, LMU Munich

Coding of chromatic information in the retina and lateral geniculate nucleus is dominated by cone-opponency, and selectivities cluster around the corresponding color-space axes. In the visual cortex, a different kind of representation is realized. Chromatic selectivities in primary visual cortex are not restricted to the cone-opponency axes, indicating a distributed representation of color. Color preferences reflect properties of the distribution of natural chromatic signals, which suggests that color processing is adapted to the statistics of the visual environment. Finally, processing of color is influenced by the visual context: Surround colors influence the tuning of color-selective neurons, and these changes are in accordance with the corresponding perceptual effects of color induction. The latter show striking similarities to contextual effects in orientation perception. These findings suggest that the cortical processing of color is based on neural mechanisms similar to those for the coding of orientation. The transformation of color signals to a distributed representation in the cortex may yield an efficient representation that enables the visual system to make use of the same neural mechanisms for the processing of different visual features.

Effects of light spectrum on the perceived colours of art paintings

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The visual impression produced by art paintings depends critically on the spectrum of the light source but the relationship between spectral structure and visual appearance is not straightforward. To study this issue, a collection of oil paintings from different époques was digitalized by spectral imaging and the data analysed to quantify the chromatic effects of illumination with various spectral profiles. Chromatic diversity, quantified by the number of colours perceived, varied considerably with the spectrum, even across illuminants with the same colour. In general, it was found that chromatic diversity was larger for highly structured spectrum. For example, from a collection of metamers of D65 those producing more colours were spectrally more structured, that is, less uniform. On the other hand, spectral optimization showed that the spectrum producing the maximum number of perceived colours was a spectrum with three peaks, in the blue, green and red spectral regions, and correlated colour temperature of about 5800 K; this spectrum could produce a number of colours about 80% higher than CIE standard illuminant D65. Together, these results suggest that a three-band illuminant may be ideal for chromatic appreciation of art paintings.

Estimation of Individual Cone Sensitivities based on Colour Matching Functions

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Estimating individual cone sensitivities [Stock2000] on the basis of individual color matching functions and a set of feasible constraints, is a classic problem of colour vision. To solve the problem one has, in effect, to postulate constraints on the shape of the cones. For example, Logvinenko [Log1998] applied a linear matching method (originally proposed by Bongard and Smirnov) which excludes of all but one primary to which each of the sensitivities of the visual system is supposedly sensitive (and, mathematically, if this constraint is met reasonable estimates should result). However, when applied to color matching functions in general, it turns out that the method estimates middle and especially long wave sensitivity quite poorly.
We propose a new method based on linear optimization, in which it is assumed only that the retinal sensitivities (photopigment spectral absorbtance functions) are known a priori [Web1988]. The method calculates a spectral pre-filter (i.e. the compounded ocular and macular filtration) that multiplied by the absorbtance functions yield an estimated set of cone fundamentals and the coefficients of the matrix that relates these cone fundamentals to the set of color matching functions. The method is tested on the 1959 10 degree Color Mathing Functions. We are also able to predict the cone sensitivities proposed by other methods.

References:

[Log1998]:
On derivation of spectral sensitivities of the human cones from trichromatic colour matching functions, Alexander D. Logvinenko, Vision Research, number 38, pages 3207-3211, 1998.

[Stock2000]:
The spectral sensitivities of the middle- and long-wavelength-sensitive cones derived from measurements in observers of known genotype, Andrew Stockman and Lindsay T. Sharpe, Vision Research number 40, pages 1711-1737, 2000.

[Web1988]:
Factors underlying individual differences in the color matches of normal observers, Michael A. Webster and Donald I. A. Macleod, JOSA-A, Volume 5, Number 10, pages 1722-1735, 1988.
The CIE data 10 degree