

## January Colour in Vision Meeting 2017

### ABSTRACTS

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#### **The role of saturation in colour naming and colour appearance**

**Christoph Witzel**  
*University of Giessen*

"Saturation is an integral part of color perception. Yet, this aspect of colour vision has been widely neglected in the investigation of colour naming and colour appearance. Several lines of evidence will be presented that show how findings on colour naming and colour appearance depend on chroma and saturation. Fundamental questions about colour naming and colour appearance must be reconsidered in the light of the important role of saturation."

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#### **Mechanisms of color: detection, discrimination, and appearance**

**Rhea T. Eskew, Jr.**  
*Department of Psychology, Northeastern University, Boston MA USA*

In 1986, Krauskopf and colleagues showed that the cardinal model of postreceptoral color mechanisms could not account for patterns of color detection and discrimination. No consensus has emerged on a computable model to take the place of the cardinal model. However, recently Shepard et al (2016) demonstrated that a model with six postreceptoral color mechanisms can account for detection (including chromatic noise masking) for stimuli that modulate the L and M cones (with no S cone modulation). The key feature of this model is an extra pair of mechanisms that oppose L and M cone signals, compared to the cardinal model that has only one such pair. New results show that forced-choice discrimination between pairs of threshold-level stimuli in the LM plane can also be accounted for by this model, in conjunction with a Bayesian Classifier approach to discrimination (Eskew et al 2001) – without any additional free parameters. Most importantly, asymmetric color matches made to the threshold stimuli fall into six clusters in the ( $u'$ ,  $v'$ ) plane and are consistent with the six mechanism model. Although most of the current findings are restricted to the LM plane, they do offer hope that a relatively simple computable model could account for chromatic detection, discrimination, and near-threshold color appearance.

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#### **The assessment of colour vision in children**

**Caterina Ripamonti**  
*Cambridge Research Systems Ltd*

The ability to discriminate colours changes across the life span and can be characterised by a bell-shape function that has its maximum at 20-30 years. After this age the colour discrimination performance decreases, due primarily to age-related ocular and neuronal changes. However, it is unclear why the performance should also be poorer in the paediatric age range. During this talk I will analyse whether the colour discrimination ability of the paediatric population reflects a real anatomical and/or functional visual development, and whether it is biased by the difficulty in performing the discrimination task, or the attentional resources required to execute the task itself.

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## Origins of Colour Preference

Anna Franklin

*The Sussex Colour Group, University of Sussex*

Although it may seem that colour preferences are idiosyncratic, research has established that some colours (e.g., blue) are more likely to be preferred and other colours are more likely to be disliked (e.g., dark yellow). It has been claimed that colour preferences are 'universal' and various theories to account for patterns of colour preference have been proposed (e.g., Palmer & Schloss, 2010; Hurlbert & Ling, 2007). Overall, research has aimed to reveal how it is that a surface of reflected light can appear to 'hold affect' (Zajonc, 1980). In this talk I will present a series of studies which we have conducted in order to understand the origins and mechanisms of colour preference. These studies investigate: i) whether infants' preference for looking longer at some colours than others relates to adult colour preference; ii) if colour preferences relate to object associations and colour naming; iii) what can account for variation in colour preference across sex and culture; iv) the impact of dichromacy on colour preference; and v) the neural basis of colour preference. I will identify limitations to current theories of colour preference and suggest the key issues that now need to be addressed.

## Cortical hyperexcitability, discomfort and colour

Arnold Wilkins

*University of Essex*

The human visual system evolved to process images from nature, which have a  $1/f$  luminance amplitude spectrum, a moderate colour contrast and little flicker. In the modern urban environment images are often unnatural in all three respects. Algorithms that assess the extent to which the image statistics depart from those in nature can explain more than 25% of the variance in judgments of the discomfort experienced when various images are viewed. There is an elevated cortical oxygenation in response to images that are un-natural and uncomfortable, consistent with computational models indicating that vision may be less efficient for such images. The oxygenation is dependent on perceptual colour contrast, not cone contrasts. In the above context we examine the clinical response to coloured filters in persons with migraine, in whom there is convergent evidence of a cortical hyperexcitability. Filters of a colour chosen individually on the basis of comfort normalise the otherwise abnormal cortical oxygenation in response to uncomfortable patterns. Individuals who have migraine with aura differ from others in their choice of colours comfortable for reading, preferring colours of stronger saturation. In individuals with autism comfortable colours improve reading speed and the ability to discern the nature and strength of the emotion expressed in faces.

## Melanopsin contributions to the representation of spatial patterns in the visual thalamus

Annette Allen, Ricardo Storchi, Nina Milosavljevic, Christopher Procyk, Franck Martial,  
& Robert Lucas.

*Faculty of Biology Medicine and Health, University of Manchester, Manchester, UK*

It is now >15 years since the discovery of a third class of photoreceptor in the mammalian retina. These intrinsically photosensitive retinal ganglion cells (ipRGCs) are quite distinct from the well-known rods and cones and employ their own photopigment (melanopsin). The accepted function of ipRGCs is to encode ambient light (irradiance) as a signal that downstream processes such as circadian clocks and sleep/arousal systems can use as a proxy for time of day. I will present evidence from electrophysiological and behavioural experiments in mice that ipRGCs also contribute to perceptual and form vision. By applying the principles of receptor silent substitution we have defined the spatiotemporal resolution of melanopsin-driven responses in the mouse dorsal lateral geniculate nucleus (dLGN) and explored their contribution to encoding spatial patterns under natural view.

## Investigating cerebral correlates of melanopic excitation responses using the metameric black framework

Françoise Viénot, Shao-Min Hung, Dan Milea, Raymond P. Najjar, Marie Dubail, Annadata Venkata Rukmini, Joshua J. Gooley, Po-Jang Hsieh

Intrinsically photosensitive melanopsin-containing retinal ganglion cell (ipRGCs) mediate crucial non-visual light responses, being involved in the entrainment of circadian rhythms, regulation of sleep, mood and other fundamental biological functions. Despite extensive recent evidence of connections between the ipRGCs and the circadian clock located in the suprachiasmatic nucleus in the brain, other cerebral projections of ipRGCs in humans remains elusive mainly because it is difficult to isolate the contribution of every family of photoreceptors. We have implemented the metameric black framework to silence rods and cones and investigate the specific melanopsin brain activation. The fMRI experiment has allowed us to disclose activation of the cortical frontal eye fields, as well as bilateral pattern activity in the inferior temporal gyri and the caudate nuclei. We will present the experiment and show how we could face inter-observer variability.

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## Variation of melanopsin signals in natural scenes

Kinjiro Amano, David H. Foster, Robert Lucas

Light incident on the eye generates both image-forming and non-image-forming responses. The image-forming response is mediated by three classes of cone photoreceptors, whose overall light sensitivity is described by the photopic luminous efficiency function, peaking at approximately 555 nm. The non-image-forming response is mediated by intrinsically photosensitive retinal ganglion cells, whose sensitivity is derived from melanopsin, peaking at approximately 480 nm. In natural scenes, the size of the two responses vary with the light incident on the scene and its reflecting properties. But can melanopsin signals in scenes be predicted from luminance signals? This question was addressed by computing luminance and melanopsin signals in over 30 hyperspectral radiance images of outdoor scenes under natural lighting, whose correlated colour temperature ranged from 3000 K to 20,000 K within scenes. The scenes contained mixtures of herbaceous vegetation, woodland, barren land, rock, and artificial objects, such as rural and urban buildings. For sampling purposes, the images were cropped to 1000 × 1000 pixels. Each was divided into 64 patches of 125 × 125 pixels to represent the effects of local scene properties. Luminance and melanopsin signals were calculated at each pixel, with allowance for prereceptor lens absorbance. The relationship between the two signals in each local area was quantified by the correlation coefficient  $R^2$ . Across scenes, the value of  $R^2$  averaged over local areas within each scene varied from 76% to 99%. But within scenes, the value of  $R^2$  varied much more from local area to local area. In one scene containing yellow flowers it ranged from 21% to 99%. These results suggest that luminance alone may be an imperfect predictor of melanopsin responses. The complex spectral structure of natural scenes and their interaction with illumination need both to be considered for reliable predictions of activity in intrinsically photosensitive retinal ganglion cells.

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## **Sculpting the light spectra to influence mood, alertness and performance: the visual/non-visual trade-off**

**Anya Hurlbert**, Guarav Gupta, Yvonne Lai, Stacey Aston, Naomi Gross, Brad Pearce  
*Institute of Neuroscience*  
*Newcastle University*

Light not only enables humans to see via the visual pathway originating in the retinal rods and cones, but also affects cognition, mood, hormone balance and biological rhythms, via the non-visual pathway now known to originate in the intrinsically photosensitive retinal ganglion cells (ipRGCs), whose spectral sensitivity peaks in the short-wavelength region. Because the visual photoreceptors also feed the ipRGCs, and because the spectral sensitivities of the visual (photopsins) and non-visual photopigments (melanopsin) overlap, it is difficult to disentangle the behavioural effects of exclusive stimulation of either. Here I describe a series of behavioural experiments in humans, in semi-naturalistic conditions, in which photopic and melanopic irradiance levels are separately modulated using spectrally tuneable multi-channel LED light sources (hi-led.eu). We find, for example, that levels of photopic irradiance comparable to those experienced in typical office settings illuminated solely by artificial lighting are sufficient to elicit melatonin suppression even without short-wavelength content. These lighting levels will disrupt circadian rhythm, as indicated by measures of sleep quality following experimental sessions. Conversely, although short-wavelength light alone – delivered in narrow-band spectra with low photopic irradiance - is extremely effective in suppressing melatonin, it impairs visual perception, worsens mood, and slows performance on tasks requiring sustained attention.

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### **Effect of Light on Alertness and Impulsivity**

**Stephen Westland**  
*School of Design*  
*University of Leeds*

The last two decades has seen increased interest in studies of the non-image-forming (NIF) component of the visual system and potential interactions with the more widely studied image-forming (IF) system. Although the NIF visual system is strongly linked with regulation of the human circadian system, it is less clear whether some other non-visual responses to colour and light (such as effect of colour on heart rate, impulsivity and alertness) are modulated solely by the NIF system or respond to activation of the IF system. This presentation will provide an overview of work that has recently been carried out at Leeds University (UK) and Zheizhang University (China) to quantify the effect of colour and light on heart rate, impulsivity and alertness. The possibilities of disentangling the effects of the IF and NIF system on various non-visual responses using a spectral lighting system will be described.

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