GLASGOW COLOUR STUDIES GROUP

Notes following the Twenty-Seventh Meeting, 25th November 2015

The twenty-seventh meeting of the GCSG took place in the Seminar Room, School of Psychology, University of Glasgow. Thanks are due to David Simmons who organized the meeting, introduced the speaker and organized the refreshments, and to Rachael Hamilton who designed the poster.

Our speaker was Prof. Sophie Wuerger, Professor of Vision Science, Institute of Psychology, Health and Society, University of Liverpool.

Prof. Sophie Wuerger spoke on 'Colour Vision Across the Life Span: Perception and Brain Imaging'

Her abstract is as follows:

Colour vision starts in the retina where light is absorbed in three different cone classes, sensitive to long-, medium-, and short-wavelength light. The cone signals then feed into three different post-receptoral channels, a luminance channel and two chromatic channels. Interestingly, these two chromatic channels do not correspond to perceptually salient colour mechanisms (red, green, yellow, blue), suggesting that the two sub-cortical chromatic channels are recombined in the visual cortex into orderly hue maps. I will discuss fMRI experiments consistent with the idea of a hue map in the visual cortex.

Secondly, I will report behavioural experiments with a large sample of adult colour-normal observers of a wide age range showing that cortical hue mechanisms are almost invariant with age. In contrast, chromatic discrimination performance declines with age.

Our results suggest that the human visual system is able to compensate for retinal (peripheral) signal changes by adjusting the relative cone weightings of the cortical colour mechanisms. Such an adaptive weighting is useful to maintain colour constancy throughout the life span in the presence of known changes in the ocular media (yellowing of the lens) and retinal sensitivity losses. It may also be responsible for the small inter-observer variability compared to the large differences in the observers' retinal make-up. The mechanism underlying this hue compensation is still poorly understood, but it is likely that it utilises invariant sources in our visual environment.

Commentary (by Carole Biggam; checked by Sophie Wuerger)

The unique hues can be identified experimentally by observers as examples of reddish or greenish stimuli which are perceived not to contain any element of yellow or blue, and examples of bluish or yellowish stimuli perceived not to contain any element of red or green. Wuerger and colleagues identified the unique hue loci of 185 observers by means of such a hue-selection task. It was found that there was a discrepancy between these unique hue loci and those of the CIECAM02 colour appearance model. While the unique hue loci are straight lines in CIECAM02, they do not converge to the origin in this appearance space. The unique

hue lines based on NCS data were then compared with the default unique hue loci in the CIECAM02 model, and this showed significant differences in unique yellow and unique blue. Hue uniformity tests showed that there was little difference for unique red with changes of lightness or chroma, whereas for unique yellow there are large changes in perceptual hue differences. These results indicate problems for colour reproduction processes which are required to produce constant hue results with different lightness and chroma elements.

What is the physiological basis for the unique hues? There is agreement that the retina encodes colour differently from the brain. We know the LGN (Lateral Geniculate Nucleus) is a relay centre between the retina and the primary visual cortex (PVC) of the brain, and that it contains six different layers of neurons. However, the PVC is more mysterious. Can we devise an experiment which confirms the LGN encoding, and perhaps reveals something of the PVC encoding?

There *are* opponent mechanisms but they are nothing to do with what we call red, green, blue and yellow; they are *cone* opponent processes. The unique hues are not aligned with the preferred LGN colours so we should avoid referring to the red-green axis etc. Multi-voxel analysis is now being used rather than fMRI (functional Magnetic Resonance Imaging). Each voxel has a slight orientation bias. To investigate how colour is encoded in the visual cortex, multi-voxel pattern classification of fMRI scans can be used. This allows us to test not only whether a brain region is *sensitive* to colour, but also how *selective* it is to particular colours.

Experiment 1 was to see whether multi-voxel pattern analysis (MVPA) reveals the spatial arrangements of colour-selective neurons in the PVC (V1), using cardinal colours. There was a high bold response to the cardinal colours in V1. Although the correlation between the two sets of colours used in the experiment was good in the LGN, they were not close in V1. It can be confirmed, therefore, that the LGN layers contain correlations but they are not the same as those in V1, and we cannot predict results for V1.

Experiment 2, perceptual hues were used, presented randomly and on more than one experimental run. The response to perceptual hues in V1 is also high, and within-category correlations are higher than between-category correlations, suggesting that neurons responding to perceptual hues are spatially clustered. It seems that it is the perceptual hues that we classify and the cardinal hues, which have strong responses in V1, cannot be classified. They must be attuned to different colours and arranged differently.

How do hues change with age? The lens yellows with age so that, by the age of about 80, bluish light no longer reaches the brain because it is absorbed by the lens. Blue cones are the worst affected by age so that, by about 60, only half of bluish light gets through. In terms of the unique hue settings there is no difference between a 30-year-old and a 60-year-old but, in terms of the signal that reaches the brain, there are big differences, since much of the bluish light is filtered out by the ageing lens. The brain seems to be able to compensate for these age-related changes, potentially by up-regulating the blue-cone signals.

News

If you have suggestions for, or offers of GCSG meetings (any format) for the next programme, please contact Carole Biggam at c.p.biggam@btinternet.com Please note that we attempt to produce a balanced programme (i.e. different disciplines) and do not necessarily accept talks

in the order in which they are offered. Nonetheless, all offers are most welcome and will be acknowledged and recorded.

Please report any colour-related news on our discussion list at ColourStudies@jiscmail.ac.uk Do feel free to ask the membership any colour questions or to begin a discussion on a particular topic.