Considerations of Stimulus Design for Vision Experiments Concerned with Maximising Receptor Ratios

For recent psychophysical experiments, where the aim was to explore the visual role of the retinal opsin melanopsin, a method was developed whereby the melanopsin ratio between two metamers could be maximised. This method is an alternative to methods utilising the theory of metameric blacks, which are well suited to experimental design where there are pre-existing multi-channel stimulus generators for which optimum values are required. This method instead starts at a ‘blank slate’ state, and considers the optimum wavelengths with which to create a source for such an experiment.

The vernacular of LED shall be used, but there is no reason that the following method could not be applied to alternative light sources, indeed a light source with an even narrower emission spectrum could be valuable for such experiments. Certain assumptions were made for simplification, but none are inherent in the method.

1. Any wavelength peak of LED is available
2. They have the same half peak width (basic model)
3. There is no heat/power related wavelength shifts
4. All channels can be independently varied

A simple and realisable metamer pair, where melanopsin is differentially stimulated, can be created through the use of four spectrally distinct narrowband LEDs, where two contribute exclusively to each of the metameric pair. The minimum requirement for metamerism in this case is that when considered in chromaticity space, the lines connecting two spectral points roughly representing the chromaticity of each narrowband LED, must cross the line connecting the chromaticities of the other two LEDs.

For example, where one is placed at or near the peak of melanopsin sensitivity (≈480nm), its complementary is chosen as a long wavelength nearing the end of the spectrum of human sensitivity (≈700nm), a third chosen as a short wavelength emitter at the other end of the spectrum (≈400nm), and a fourth chosen to counter it. This fourth placement represents the most interesting choice; placement here needs to be between the first and second wavelength chosen (480-700 here) so as to satisfy the above minimum requirement, but choice within that range is pivotal for limiting the melanopsin contribution whilst ensuring that the chromaticity of the eventual metamers allows for substantial contribution from the melanopsin centred LED. It is this optimization problem which shall be discussed in further length in this paper.

It is hoped that sharing this method might be beneficial to other researchers designing related experiments.