THE ROLE OF SHORT-WAVELENGTH LIGHT IN HUMAN BRIGHTNESS PERCEPTION

by

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ABSTRACT

Several studies have shown that for the same photopic illuminance and for a large visual field, perceived brightness increases towards the shorter wavelengths of light between 430 nm and 500 nm. This study was designed to investigate the effect of different spectra and levels of light underlying the short-wavelength light contribution to human brightness perception. 10^o photopic luminous efficiency function $V_{10}(\lambda)$, which has been used to represent the spectral sensitivity of the extra-foveal visual fields, was compared to the experimental results. The general hypothesis was that $V_{10}(\lambda)$ underestimates the contribution of short-wavelength light to brightness perception and thus will not be able to accurately scale the results of the experiment.

In order to test this hypothesis, four pilot studies were conducted to aid in the development of the main dichoptic experiment. A special optical apparatus was designed to divide the field of vision into two distinct scenes where each eye was treated separately with different set of light stimuli so that the temporal changes and memory of the visual system was minimized.

Eight subjects participated in the main experiment, first trying to match a test brightness field seen with one eye to a reference field seen with the other eye. Light stimuli at 480-nm and 630-nm spectra were used as the test fields whereas light stimulus at 436-nm spectrum was the reference. The participants' brightness matching results were used to define their "50% bright" reference conditions for 480-nm and 630-nm spectra as they proceeded to the brightness rating section of the experiment. In this section, one eye of each participant was provided with five different irradiances within two orders of magnitude and at three light spectra. They were shown the "50% bright" reference condition for each spectrum and were asked to assign brightness ratings for the subsequent set of irradiances. Throughout the experiment, different irradiances and spectra were shown to the participants in a counterbalanced fashion. Participants were given a one minute adaptation time before each judgment. The brightness ratings were recorded and analyzed by determining the

amount of stimulus required to evoke the same brightness measure for each participant.

The results suggested that brightness perceptions of the three spectra (436-nm, 480-nm and 630-nm) at the same photopic illuminance were not consistent with a $V_{10}(\lambda)$ spectral sensitivity function. Specifically, brightness sensitivities to the 480-nm and 630-nm spectra were consistent with a $V_{10}(\lambda)$ spectral sensitivity, but brightness sensitivity to the 436-nm spectrum was greater than predicted by $V_{10}(\lambda)$ spectral sensitivity function once the sensitivities for 480 nm and 630 nm spectra were scaled.

In addition to the general hypothesis, it was also hypothesized that the relationship between 436-nm, 480-nm and 630-nm would change systematically with light level. Specifically, according to the brightness model by Rea et al. (2010), if the contribution of short-wavelength light to brightness perception increases as light level increases, then the ratio of irradiances 436-nm to 630-nm spectra (436 nm/630 nm) and 480-nm to 630-nm spectra (480 nm/630 nm) will decrease. The results of the experiment do not show a systematic increase in brightness ratios as light levels were increased.

Further research will have to be conducted to investigate the photoreceptor interactions underlying this short-wavelength light contribution to brightness perception.