Variability in chromatic sensitivity in normal colour vision and in congenital deficiency

J. L. Barbur, M. Rodríguez-Carmona & J.A. Harlow

Applied Vision Research Centre, The Henry Wellcome Laboratories for Vision Sciences, City University, London UK.

We examined the inherent variability in chromatic sensitivity in relation to Rayleigh matches (under dark field conditions) and measurements of red/green (RG) colour thresholds in normal and colour deficients, when adapted to daylight (D_{65}). The existence of variant L and M cone pigment genes within normal trichromats and the consequent variation in peak wavelength separation remains largely undetected both in Rayleigh match parameters and in colour detection thresholds. The Nagel anomaloscope matches were modeled to predict how the wavelength of peak sensitivity and optical density of cones and the noise amplitude in the RG channel affect the midpoint and the matching range (Barbur, Rodriguez-Carmona, et al., 2008: *Vis.Neurosci.* 25 (3):507-516). The model predicts well the variability in Nagel parameters observed in normal trichromats and also in colour deficients. The predictions include the observed lack of correlation between match midpoint and matching range in normal subjects, the normal matching range values measured in many deuteranomalous and protanomalous observers and the normal match midpoint and range observed in some subjects with chromatic sensitivity typical of minimal deuteranomaly. The size of the matching range shows no correlation with the subject's light-adapted, RG thresholds. In order to account for these findings we modeled RG chromatic sensitivity thresholds using two sources of noise. The model assumes that the first source of noise is subject-specific and related to the relative numbers of L and M cones in the retina. This we label as cone photoreceptor signal amplification noise which limits chromatic sensitivity under dark field conditions (typical of anomaloscope matches). The second source of noise, the "neural" noise is assumed to be the same for all subjects and limits chromatic sensitivity when the retina is light adapted. These findings suggest that different factors affect the subject's chromatic sensitivity in the two conditions and explain why the anomaloscope matching range fails to predict the subject's chromatic sensitivity under more natural conditions of light adaptation.

Supported by the Civil Aviation Authority (UK), grant number 474/SRG/R