Temporal characteristics of the short-wavelength-sensitive cones and their associated pathways

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Many morphologically and functionally distinct retinal ganglion and LGN cell types have been characterised, several of which have opponent cone inputs and so may carry chromatic information. Of interest are the asymmetries in LGN cells carrying S-cone signals: S+ signals are opposed by (L+M), whereas L+ signals are opposed by (S+M), giving –S+L–M (Tailby et al., 2008, *J Neuroscience*). The traditional model of opponent colour processing, however, assumes that chromatic information is transmitted to the brain in just two independent pathways: one encoding ±[L–M] cone responses, and the other encoding ±[S–(L+M)] responses. We challenge the predictions of this model in a psychophysical task. Simultaneous sinusoidal modulations of L–M and S–(L+M) result in procession around an elliptical locus in the MacLeod-Boynton chromaticity diagram, with eccentricity dependent on the relative phase of the modulations. Under conditions in which the visited hues fall on a circular locus at 10Hz, observers can discriminate clockwise and counterclockwise processions, which implies that the loci are distorted by neural delays prior to the site of combination of the component modulations (Stromeyer et al., 1991, *Vis Res*). Indeed, there is independent evidence that S-cone signals arrive at a central site some milliseconds after L-M signals. Introducing a physical delay renders clockwise and counterclockwise processions indiscriminable. Conversely, when we use component modulations intermediate to the cardinal mechanisms we find no physical delays at which discrimination is impossible. Our results support the classical model in which chromatic information is carried to a central site by only two independent mechanisms. Comparing our data to simulations suggests that –S+L–M signals do not provide an additional dimension that supports discrimination of hue loci. We estimate a delay in the S-cone pathway of 12ms relative to L–M opponent modulations, but cannot say exactly where this delay arises.

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