Key Note

# Chapter 4: Seeing in colour

## Key note 4A: Peculiarities of the S cone system

In this note, we describe studies of the spatial and temporal resolution of the S cone system, which both appear to be worse than those of the L and M cones.

The S (blue) cone system appears to be different in several respects to those of the L and M cones. Because it is fed from fewer cones (and S cones are sparse in or absent from the fovea), it might be expected that the spatial resolution of the S cone system is low, an idea tested by Humanski and Wilson (1993) in a study of adaptation to gratings. These authors wanted to be sure that L and M cones could not be contributing to the perception of their stimuli, so their gratings of light and dark blue stripes were presented on an intense uniform yellow field, which would bleach out the pigment in L and M cones, making them insensitive. After initially adapting to the yellow field for 3 minutes, the observers adapted for 4 minutes to the yellow field and superimposed high contrast blue grating. The task was to decide in which of two intervals a subsequently presented low contrast test grating had appeared. From the contrast thresholds for test gratings of different spatial frequencies, the authors could calculate the peak sensitivities and bandwidths of the underlying mechanisms. They concluded that S cones fed three spatial mechanisms, two with peak sensitivities of 0.7 and 1.4 c deg−1, and one which handled spatial frequencies below 0.35 c deg−1. None responded to spatial frequencies above about 4 c deg−1. These values compare with a peak sensitivity of 16 c deg−1 for the highest spatial frequency mechanism responding to luminance modulated gratings (see Chapter 5).

It also appears that the S − (L + M) system responds more slowly than does the L − M system. Smithson and Mollon (2004) tested this idea in humans by measuring reaction times. Their displays were composed of arrays of randomly positioned discs, whose luminance was jittered about the overall mean, rather like that of the Ishihara plates (see Chapter 3 in the book), on a uniform background of the same hue as the discs. The target was an arc of such discs occupying one quarter of an imaginary annulus with the fixation point at its centre, produced by a small change in hue, close to detection threshold. Before the experiment proper, the authors measured each observer’s tritan confusion line, that is, the axis in colour space along which a change of hue affects only the S cones, for the retinal positions on which the target could fall. The most interesting comparison in their study is between reaction times when the S cones were stimulated (by a change in hue along the tritan line) and when the change in target hue was along the L−M axis (as established by others). Reaction times to the S cone stimuli were 20–30 ms longer than those to the L−M stimuli, suggesting that indeed the S cone system is more sluggish.

Humanski RA, Wilson HR (1993) Spatial frequency adaptation: evidence for a multiple channel model of short-wavelength-sensitive-cone spatial vision. *Vision Research* 33(5/6): 665–675.

Smithson HE, Mollon JD (2004) Is the S-opponent chromatic sub-system sluggish? *Vision Research* 44: 2919–2929.