DAVID BRAINARD
Department of Psychology, University of Pennsylvania

Color, Cones, and Bayesian Modeling: Understanding the Appearance of Small Spot Colors

Color, Cones, and Bayesian Modeling: Understanding the Appearance of Small Spot Colors Human color vision is mediated by three classes of cones, each characterized by its own spectral sensitivity. It is this biological fact that underlies behavioral trichromacy, so that essentially any light may be matched by a mixture of three primaries. The human cone mosaic, however, has an interleaved structure, so that at each location there is only one cone. Thus the trichromacy observed for spatially extended stimuli must result from a combination of color information over space. I present a Bayesian calculation that models this integration of information from individual cones. The calculation accounts for a variety of perceptual phenomena. In particular, it can be elaborated into a quantitative model for the appearance of very small monochromatic spots. Empirically, observers provide a wide range of color names in response to spots with a retinal size comparable to that of a single cone (achieved through the use of adaptive optics, Hofer et al., 2005). To model this, I start with the simulated responses of the individual L-, M-, and S- cones actually present in the cone mosaic and use the Bayesian calculation to estimate the trichromatic L-, M-, and S-cone signals that were present at every image location. The calculation incorporates precise measurements of the optics and chromatic topography of the cone mosaic in individual observers, as well as the spatio-chromatic statistics of natural images. I carefully simulated the experimental procedures of Hofer et al., and predicted the color name on each simulated trial from the average chromaticity of the LMS image estimated by our calculation. There were no free parameters to describe individual observers, but none-the-less the striking individual variation in naming emerged naturally as a consequence of the measured individual variation in the relative numbers and arrangement of L-, M- and S-cones. The model also makes testable predictions for experiments that may soon be feasible, including how color naming should vary with spot size and with the fine structure of the retinal mosaic.