Human red-green chrominance contrast sensitivity is matched to the spatiochromatic Fourier spectra of images of fruit in foliage

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Recent research on the relationship between ecology and primate vision has revealed that the red-green channel in primate vision is optimised to the encoding of the chromatic difference between mature, green foliage and edible fruit or yellowish leaves (Osorio & Vorobyev, 1996; Sumner & Mollon, 2000; Dominy & Lucas, 2001). There has been less consideration of the relationship between the chromatic content of such scenes and their spatial-frequency content. The human visual system encodes spatial changes in luminance as a Fourier band-pass function while spatial chrominance changes are encoded as a low-pass function, with lower spatial resolution (Mullen, 1985), and it is tempting to ask whether this difference reflects a property of the natural world. PÃ¡rraga et al. (1998) found no difference between the luminance and chrominance Fourier spectra of digitised images of natural scenes, but the study did not consider any particular task for the visual system to perform, nor any particular type and magnification of image.
We obtained 91 digital images of fruit, and other scenes, using a custom-calibrated Nikon 950 digital camera. For each pixel in a 512x512 image, the camera's tricolour values were converted to human long-, medium- and short-wavelength (L, M and S, respectively) cone sensitivities and then into luminance (L+M) and red-green chrominance (L-M)/(L+M) values. The luminance and chrominance versions of each image were Fourier-analysed and the slopes of their amplitude spectra measured.
The Fourier spectra were fitted by straight lines on log-log axes. The luminance and chrominance images of landscape scenes have similar spectra, with slopes of about -1.0, as found by PÃ¡rraga et al. (1998). However, scenes containing red fruit or other targets against foliage tend to have steeper spectra. Now, chrominance spectra are steeper than luminance ones (slope -1.4 to -1.8 vs. -1.2 to-1.5), particularly for close-ups where red fruit occupy more than 10 % of the total area of the image.
The steeper chrominance spectra are consistent with the low acuity of the human red-green channel, implying that its spatial properties are optimised for the detection of a class of objects which reflect longer wavelengths than the green leaves and which are relatively close.This work was supported by the BBSRC.