Appendix S1: Additional methodological details.

PHOTORECEPTOR ABSORPTION FUNCTIONS FOR _ANOLIS LINEATOPUS_

We estimated the shape of absorption of each of the four pigment classes using Lamb’s photoreceptor template (Lamb 1995) and maximum absorption values from Loew _et al._ (2002). We calculated the effects of oil droplet filters using the most common combinations of single cones and oil droplets (Fleishman & Persons 2001; Loew _et al._ 2002) following Hart & Vorobyev (2005) using a value of $b=0.05$ and estimated $\lambda_0$ values from oil droplet measurements (Loew _et al._ 2002). Chromatic perception is based on the relative stimulation of the four classes of single cones (see below). In this paper we use luminance to estimate perceived intensity independent of chromatic sensation. We used the absorption function of the double l cones to represent the _Anolis lineatopus_ luminance function. Earlier behavioral and neurophysiological studies have shown that this function can be used to accurately estimate luminance (Persons _et al._ 1999; Fleishman & Persons 2001).

ESTIMATING QUANTAL CAPTURE RATES OF INDIVIDUAL PHOTORECEPTORS

Fleishman, Ogas, Steinberg, Leal
In order to test the effects of absolute signal intensity on color discrimination thresholds it is necessary to determine the spectral sensitivity of a photoreceptor in units of photon capture per second. This can be calculated as follows (following Vorobyev 2003):

\[
S_{\lambda}(\lambda) = n t \left(\frac{\pi}{4}\right)^2 \Delta r^2 d^2 \left(1 - \exp\left(-\mu_{\lambda}(\lambda) t\right)\right)
\]

\textit{n = the number of cones per ganglion cell field.} Based on microspectrophotometry (MSP) and electroretinography (Fleishman \textit{et al.} 1997; Loew \textit{et al.} 2002) we roughly estimate that uv, s, and m cones occur at equal densities. We are unsure of the relative density of single l cones, because they overlap in sensitivity with the much more common double l cones, and during MSP, single members of double l cones often break off. In many animals groups (see Endler & Mielke 2005) l cones are more common than the other types. Here we assumed that single l cones are three times as common as the other single l cones. However we also tested our results with other ratios, including equal numbers of all cone classes, and found no qualitative difference in the outcome. We also assumed a pooling of photoreceptors of five cones per receptive field.

We also considered the possibility that more spatial pooling might occur at lower light levels. We tested this with a behavioral experiment and found that spatial resolution did not change with reduced light level (Fleishman, unpublished data).

Apparently anoles, with a relatively small eye and high acuity visual system do not undergo a great deal of increased photoreceptor pooling at low light levels.


\( t = \text{temporal integration.} \) We followed Vorobyev (2003) and used the reciprocal of critical frequency of fusion (CFF) to estimate retinal integration time. Fleishman, Marshall & Hertz (1995) measured this in three anoline species at three light intensities. We averaged the results from three species and determined that \( t = 3.5(\log_{10}(I)+14.5) \), where \( I \) is measured in irradiance (\( \mu \text{mol m}^{-2} \text{s}^{-1} \)) normal to the surface of the eye.

\( \Delta r = \text{acceptance angle of individual photoreceptor} = (\text{receptor diameter}/\text{distance from retina to nodal point of eye}). \) We used a receptor diameter of 1.2 \( \mu \text{m} \) (from Underwood 1970). Nodal distance was based on the calculation presented in (New 2012) for the lizard *Amphibolurus muricatus*, which has an eye shape very similar to *A. lineatopus*. We scaled the calculation to match the *Anolis* eye.

\( d = \text{pupil diameter.} \) We used 1mm based on Underwood (1970).

\( \mu_i(\lambda) = \text{optical density if pigment type } i \text{ as a function of wavelength.} \) We used a maximum value, \( \mu_i(max) = 0.015 \mu \text{m}^{2} \) based on Vorobyev’s (2003) estimate for bird cones. If the relative sensitivity of cone pigments (including oil droplet filtering) = \( C_i(\lambda) \), then \( \mu_i(\lambda) = C_i(\lambda) \times \mu_i(max) \).

\( l = \text{outer segment length.} \) Based on drawings by Underwood (1970) of *A. lineatopus* cones we estimated 8 \( \mu \text{m} \) for m and l cones and 7 \( \mu \text{m} \) for s and u cones.

References


Fleishman, Ogas, Steinberg, Leal