

Costs and benefits of higher-order color mechanisms.

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Psychophysics and electrophysiology agree that from striate cortex to posterior infero-temporal cortex, the three color signals transmitted by the retina are processed by neurons whose preferred stimuli are distributed widely in hue directions, and whose tuning progressively narrows in color space. Previous studies have concentrated on evidence for these higher-order mechanisms, this study analyzes the computational costs and benefits of expanding the neural dimensions of color signals.

For decoding spatially-uniform colors, higher-order mechanisms provide a small temporal advantage but some accuracy problems. Optimal decoding schemes, interval or population based, effectively involve narrow color tuning, which could be achieved by spike-coincidence detectors. A decision stage using vector sums leads to systematic mean biases in decoding, depending on the distribution of preferred directions, whereas using the peak of the population response leads to larger estimation variability.

In mid-level vision tasks involving spatio-temporal color variations, higher-order mechanisms provide many advantages over three cardinal mechanisms and their six rectified versions. Higher-order mechanisms enable adaptation levels to be separated for different color-contrast directions, thus enhancing sensitivity to novel stimuli. Similarly, higher-order mechanisms improve segmentation of variegated color images, and discrimination of colored textures, by separating non-cardinal variations from their orthogonal counterparts. If color induction were confined to cardinal mechanisms, the differences in their contrast-responses would lead to disturbing changes in object hues. Finally search in color-clutter is more efficient when conducted through mechanisms tuned to many different color directions.

Observers can recognize objects and scenes extremely rapidly, which suggests that feed-forward neural transformations achieve efficient object representations. Higher-order mechanisms increase the number of neural dimensions in which objects and scenes can be represented across viewing and lighting conditions. We are examining whether representations for individual objects form simple surfaces in high-dimensional color spaces, thus enabling simpler linear decision rules for rapid object and scene classification.

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