Disparity and luminance preference are correlated in macaque V1, matching natural scene statistics

Brian Potetz, Jason M. Samonds, & Tai Sing Lee

Center for the Neural Basis of Cognition, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213, USA

Since Leonardo da Vinci, artists and psychologists have known that, all other things being equal, brighter stimuli are perceived to be closer than darker stimuli. Recent statistical studies of natural, laser-scanned 3D scenes (Potetz and Lee 2003, JOSA) have shown that this perceptual effect has an ecological basis: brighter image regions tend to be closer to the observer in real-world scenes. The correlation is thought to arise from shadowing: concave surfaces and object interiors tend to be more shadowed than convex surfaces. In natural scenes, this cue is often more powerful than shading cues for inferring depth from single images (Potetz and Lee 2006, NIPS). Computational theories of perceptual encoding such as redundancy reduction predict that neurons should be more likely to prefer common stimuli (such as near and bright) than less common stimuli (such as near and dark). To test this theory, we measured disparity tuning for V1 neurons of awake, behaving macaques using dynamic random dot stereograms in a 4 degree aperture. We also measured the response of each neuron to a 4 degree luminance disk (with one of 7 luminance levels) against a gray background. Luminance preference was quantified as the difference between firing rates for the light and dark disks. We evaluated the correlation between the preferred disparity and the luminance preference of the disparity-tuned neurons using several different metrics. Regardless of the metric used, we found that there is a significant correlation between depth and luminance preferences: neurons that are near-tuned tend to prefer relatively brighter disks, while neurons that are far-tuned tend to prefer relatively darker disks. We also found that the selective response to luminance was delayed relative to disparity tuning, suggesting that not only bottom-up connections, but also recurrent connections encode the correlation between disparity tuning and luminance tuning in V1.

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