A computational model predicts discrimination thresholds for morphed objects in natural scenes

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We have previously shown that the human visual system is optimised to encode the information in the natural visual environment. This has been demonstrated psychophysically by comparing people's discrimination thresholds for small spatial changes (produced by 'morphing') in natural and unnatural (spectral slope modified) visual stimuli. We have now developed a relatively simple computational model of the low-level discrimination process to explain these results. We calculate differences in contrast between two images (reference and test) within a number of spatial-frequency channels designed to have the spatial-frequency bandwidth of simple cells in the visual cortex (about 1 - 1.5 octaves). Our model presumes that simple cells in several independent spatial-frequency bands sample the reference and test stimuli point-by-point, and that each cell then signals any local differences in the spatial structure of the two stimuli. By 'customising' the model to include each observer's contrast sensitivity to sinusoidal gratings, we are able to replicate the forms of the relationships between discrimination threshold and spectral slope, and the ways that these differ between picture sets and observers. Our results support the view that many of the properties of the human visual system (bandwidths of neural filters, shape of the contrast sensitivity function, etc) are tuned for optimal performance for discrimination tasks in a natural environment.