Natural image statistics and visual processing. Are they matched?

C. Alejandro Parraga, D.J. Tolhurst, Tom Troscianko

It has been suggested that the overall organisation of the visual system, including the response properties of individual neurons, might be optimised for encoding the statistical information content of natural scenes. However plausible it might be, the suggestion still remains to be fully validated experimentally. Here we propose a new method for investigating whether the presence of natural statistics does indeed optimise the discriminability of natural scenes. Our aim is to use a set of stimuli which, while plausible, still allows good experimental control. A morphed sequence of natural scenes was presented to observers in a modified two-alternative forced-choice experiment. They were asked to discriminate between reference (original) images and a slightly morphed version of these. Discrimination thresholds were obtained by fitting the measured psychometric function with the integral of a normal distribution. The statistics of each morphed sequence were manipulated by controlling the falloff of Fourier amplitude with spatial frequency (alpha), and thresholds for morphed sequences with different alpha values were measured. Eleven different conditions were explored with amplitude slopes ranging from -0.5 (whitened or edge-enhanced pictures) to -2.5 (blurry pictures). The results show that morphed scenes having an alpha value close to that reported for natural scenes (c339b1.jpg= -1.2) are optimally discriminated by the human visual system. We conclude that natural stimuli are optimally discriminated, and suggest that this method may be suitable for more general investigations with naturalistic stimuli.