

Spatial phase related nonlinearity in alignment of contours

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Neurons involved in early visual processing are often tuned to narrow bands of spatial frequencies. In contrast, important image features such as edges are often broadband, comprising precisely positioned narrow-band components. Merely perturbing the relative positions (i.e. phase) of these components will destroy the image feature. If broadband features are ecologically critical for form perception, then there must exist nonlinear mechanisms that combine the outputs of front-end narrow-band neurons for the detection and discrimination of these features. This study examines the presence of these non-linear mechanisms. We asked observers to detect the misalignment of 2 identical, vertically separated patterns, each windowed by a circular Gaussian, at near-fovea and 5 deg eccentricity. Each pattern in the in-phase condition was a vertical bar with sharp edges. Patterns in the out-of-phase condition were phase-scrambled versions of the in-phase stimuli. An ideal-observer's alignment threshold for these patterns was the same since their auto-correlation functions were identical. At near-fovea, the two patterns were separated by 1 deg and the in-phase bar width and the space constant of the Gaussian window were 0.1 deg. Stimuli at 5 deg eccentricity were scaled (10x) versions of the foveal stimuli. Averaged alignment threshold for the in-phase condition was 0.03 deg at near-fovea and 0.11 deg at 5 deg eccentricity. Phase-scrambling had little effect on the foveal threshold, but elevated the peripheral threshold by a factor of 2.3. Results were similar when a single edge was used instead of a bar. Our results suggest that contour alignment relies in part on nonlinear broadband mechanisms for sharp edges. We speculate that in the fovea, a dense array of different nonlinear broadband mechanisms may form a complete basis set, allowing an effectively linear representation of the input; whereas in the periphery, sparse placement of these mechanisms "uncloaks" their nonlinearity.

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