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Higher-Level Neural Specialization for Natural Shape Statistics

(NEI R01-EY017205 FY 05)

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Our objective is to discover how neural processing in high-level visual cortex is specialized to exploit the statistics of natural object shape. Images of natural objects have complex and unique structural statistics imposed by gravity, lighting, material properties, biological processes, architecture, and standard observer viewpoints. The visual system is specialized to focus on the most useful available shape information for recognizing, understanding and interacting with objects. This statistical specialization helps make biological vision superior to current machine vision systems. Previous studies have focused on specialization of early visual processing stages for general scene statistics. We aim to investigate specialization of higher-level visual processing stages for complex object shape statistics. In recent neurophysiological studies, we have mathematically characterized neural tuning for complex shape in higher-level regions visual cortex of macaque monkeys. Neurons in these areas show Gaussian tuning along multiple shape dimensions, including retinotopic spatial position, object-relative spatial position, orientation and curvature of contour fragments. At the highest stages in temporal visual cortex, neurons integrate information across multiple tuning regions (and thus across multiple contour fragments). Across neural populations, there are substantial anisotropies in the distributions of tuning values and higher-order relationships between multiple tuning regions. Our preliminary analyses of first order shape characteristics suggest how these anisotropies reflect (1) the statistical distribution of shape properties across natural objects and (2) regions of low overlap and therefore high discriminative value between objects. Thus, neural tuning in higher-level visual cortex is specialized simultaneously for the most common and the most informative aspects of the available shape information in natural objects. We project that higher-order analyses will reveal even more specific correlations between neural tuning and natural object structure.

Project (or PI) Website

http://www.mb.jhu.edu/connor.asp