Selectivity for Mirror-Symmetric Views of Faces in the Ventral and Dorsal Streams of the Human Visual System

Tim Kietzmann[1,2], Jascha Swisher[1], Peter König[1,3], & Frank Tong[1]

[1] Vanderbilt Vision Research Center, Psychology Department, Vanderbilt University
[2] NeuroBioPsychology Lab, Institute of Cognitive Science, University of Osnabrück
[3] Department of Neurophysiology and Pathophysiology, University Medical Center Hamburg-Eppendorf

Although the ability to recognize faces and objects from a variety of viewing angles is crucial to our everyday behavior, the underlying cortical mechanisms are not well understood. Recently, specific neurons in the macaque inferior temporal lobe were found to be selective for mirror-symmetric views of faces rotated in depth, and not responsive to intermediate views (Freiwald & Tsao, 2010). This property has been suggested to constitute a key computational step in achieving full view-invariance. Using fMRI and multivariate pattern analysis (MVPA), we investigated whether such selectivity for mirror symmetry might also be found in human visual cortex. We measured BOLD activity in nine observers, as they viewed upright or inverted faces presented at five different angles (-60, -30, 0, 30, 60 degrees). To estimate the effects of viewpoint symmetry, we tested whether the activation patterns for mirror-symmetric views (e.g., -60 and 60 degrees) were more similar than those involving non-symmetric views (e.g., -60 and 0 degrees). Two analyses were performed, one on predefined ROIs and one based on a searchlight technique. We found that viewpoint-symmetric response patterns are prevalent in the human visual system. Importantly, these mirror-symmetric activity patterns were not confined to a single face-selective area. Instead, the effect was present in a large band of higher-order visual areas, including the occipital face area, posterior and anterior segments of the fusiform face area, as well as the lateral occipital complex, parahippocampal place area, and extending superiorly to encompass dorsal regions in the posterior intraparietal sulcus. Critically, early retinotopic regions V1-hV4 did not show these effects. Our findings suggest that the selectivity for mirror-symmetric viewpoints may constitute a general intermediate-level processing step shared across multiple higher-order areas of the visual system, setting the stage for complete viewpoint-invariant visual representations in more anterior areas of the visual hierarchy.

Acknowledgements: Supported by NSF grant BCS-0642633 to FT, F32-EY019448 NEI Fellowship to JDS, ERC 269716 Multisense to PK, a Fullbright fellowship to TCK, and P30 EY008126 to the Vanderbilt Vision Research Center.