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The occipitotemporal or “ventral” visual pathway contributes to stereopsis

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Aim One of the major tasks of the visual system is to derive depth of visual features and construct a 3-dimensional scene from the left and right retinal images. The computation for binocular depth perception or stereopsis starts in the primary visual cortex, V1, where signals from the two eyes converge onto single neurons and binocular information is encoded. It was once thought that the computation for stereopsis is then performed mainly along the occipitoparietal or “dorsal” visual pathway. Recent findings from our and other laboratories, however, indicate that a large population of neurons in cortical areas along the occipitotemporal or “ventral” visual pathway, such as area V4 and the inferior temporal cortex (IT), are sensitive to binocular disparity. Here, we examine the functional involvement of these disparity-selective neurons in V4 and IT in stereopsis.

Methods We recorded extracellular action potentials from neurons in V4 and IT of Japanese macaque monkeys engaged in either fine depth discrimination tasks (Exp. 1) or fixation tasks (Exps. 2, 3). **Exp. 1:** Monkeys were subjected to two-alternative forced choices to discriminate whether a target stimulus was located in front of or behind the fixation point. Near the psychophysical threshold, the perceptual depth judgment of a monkey for a given visual target fluctuates across trials, as does neuronal activity. During every trial, we recorded both the responses of IT neurons elicited by the stimulus and the behavioral choice made by the monkey. **Exp. 2:** Humans and monkeys cannot perceive depth when the dots of a random-dot stereogram (RDS) are contrast-reversed between the image seen by the right-eye and that by the left-eye. We examined the responses of V4 neurons to normal and contrast-reversed RDSs. **Exp. 3:** Psychophysical depth judgments depend primarily on relative disparities between features, objects or surfaces within a scene. We recorded the responses of V4 cells to concentric-bipartite RDSs to examine the encoding of relative disparities between the center disk and the surrounding annulus.

Results **Exp. 1:** Receiver-operating characteristics analysis demonstrated that trial-to-trial fluctuations of IT-cell responses to a given disparity stimulus correlated with the animal’s behavioral report of depth judgment. Assessment of the neural activity in IT thus provided a prediction of the monkey’s subsequent choice above the chance level. **Exp. 2:** When the RDS was contrast-reversed, the majority of disparity-selective V4 neurons attenuated their disparity-selectivity, a decrease in sensitivity also reflected in depth perception. **Exp. 3:** In the plots of neural responses vs. absolute disparity, most V4 neurons shifted their tuning curve sideways along the disparity axis when tested with different disparities at the surround. The unimodal distribution of the shift was highly biased towards the direction expected for relative disparity coding.

Discussion The results of Exp. 1 suggest that disparity signals in IT are functionally involved in the fine localization of objects in depth direction. The results in Exp. 2,

together with previously published results from other laboratories, suggest that activity in V4 surpasses the local filter-like processing of V1, and correlates more with binocular depth perception in the tested aspect than that seen in MT. A comparison of the results in Exp. 3 with those for V1, V2, and MT demonstrates that V4 has a substantially higher sensitivity for relative disparity than the other areas. This series of experiments indicate that disparity signals in the ventral visual pathway are transformed from signals based on absolute-disparity to relative-disparity based signals, contributing to perceptual tasks that require fine-grade disparity discrimination.

References

1. Uka T, Tanaka H, Yoshiyama K, Kato M, Fujita I (2000) Disparity selectivity of neurons in monkey inferior temporal cortex. *J Neurophysiol* 84, 120-132.
2. Tanaka H, Uka T, Yoshiyama K, Kato M, Fujita I (2001) Processing of shape defined by disparity in monkey inferior temporal cortex. *J Neurophysiol* 85, 735-744.
3. Shimojo S, Paradiso M, Fujita I (2001) What visual perception tells us about mind and brain. *Proc Nat Acad Sci* 98, 12340-12341.
4. Watanabe M, Tanaka H, Uka T, Fujita I (2002) Disparity-selective neurons in area V4 of macaque monkeys. *J Neurophysiol* 87, 1960-1973.
5. Fujita, I (2002) The inferior temporal cortex: architecture, computation, and representation. *J Neurocytol* 31, 359-371.
6. Yoshiyama K, Uka T, Tanaka H, Fujita I (2004) Architecture of binocular disparity processing in monkey inferior temporal cortex. *Neurosci Res*, in press.
7. Tanabe S, Umeda K, Fujita I (2004) Rejection of false-matches for binocular correspondence in macaque visual cortical area V4. *J Neurosci.*, in press
8. Uka T, Tanabe S, Watanabe M, Fujita I Neural correlates of fine depth localization in macaque inferior temporal cortex. Submitted.
9. Umeda K, Tanabe S, Fujita I (2004) Coding of relative disparity in monkey visual area V4. *Vision Sciences Soc Abstr.*