Cooperative processing of spatially distributed disparity signals in macaque V1

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Although there has been substantial progress in understanding the neurophysiological mechanisms of stereopsis, many questions remain about how the brain solves the correspondence problem. To gain insight into how horizontal disparity signals are spatially integrated and might solve the correspondence problem, we simultaneously recorded from multiple neurons in V1 of awake, alert macaques while displaying dynamic random dot stereograms. Physical distances between neurons ranged from 1 to over 3 mm, and receptive field separation ranged from partially overlapping to 2º. We quantified the functional connectivity among neurons using the correlation coefficient integrated from normalized cross-correlograms for ±25 ms lag times. The functional connectivity between disparity tuned neurons depended on the disparity of the stimulus. The tuning based on functional connectivity was narrower and more robust than predicted by the independent firing rate tuning curves. To determine how disparity estimates might improve over time (i.e., coarse-to-fine), we examined the temporal evolution of disparity tuning. We found that the firing rate-based disparity tuning was initially very broad. The functional connectivity-based disparity tuning emerged shortly after and was much narrower. Functional connectivity continued to strengthen as the firing rate tuning became sharper. Our results suggest that a coarse-to-fine mechanism likely interacts with, and may even arise from, cooperative processing that allows the brain to converge to a correspondence solution.

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