Synchronous activity in cat visual cortex encodes collinear and cocircular contours

Zhiyi Zhou¹, Jason M. Samonds²†, Melanie R. Bernard† & A. B. Bonds¹,²

¹ Department of Biomedical Engineering, Vanderbilt University, Nashville, Tennessee 37235, USA

² Department of Electrical Engineering and Computer Science, Vanderbilt University, Nashville, Tennessee 37235, USA

† Present address: Department of Computer Science and the Center for Neural Basis of Cognition, Carnegie Mellon University, Pittsburgh, Pennsylvania

Synchronous neural activity has been proposed as a possible foundation for perceiving coherent visual stimuli. We found that synchronous activity in cat visual cortex is more reliable in detecting collinear or cocircular contours than changes in firing rate. A 10x10 microelectrode array was used to record from 51 cells in areas 17 and 18 in two paralyzed and anesthetized cats. We used drifting sinusoid gratings and concentric rings for collinear and cocircular stimulation. We studied cell pairs with minimal overlapped receptive fields and defined cocircularity as the orientation difference within a cell pair. We classified cell pairs with cocircularity ≥ 10° as cocircular (N = 51) if they were tangent to the same circle, and those with cocircularity < 10° as collinear (N = 76). The relationship between the stimulus and receptive fields predicts that collinear and cocircular cell pairs would show different activation for rings versus gratings. Collinear cell pairs showed greater synchrony under drifting grating stimulation than under concentric ring stimulation. In contrast, cocircular cell pairs showed greater synchrony under concentric ring stimulation than under drifting grating stimulation. The relative synchrony from rings versus gratings increases in cocircular cell pairs as cocircularity becomes greater, and decreases in collinear cell pairs as cocircularity becomes more negative. The relative total firing rate showed no patterned dependence on cocircularity in either collinear or cocircular cell pairs. Regression analysis (N = 127) for synchrony and firing rate versus cocircularity provides evidence that synchrony is more sensitive and reliable than response rates in detecting both collinear and cocircular stimulation. We believe that coherent perception is maintained through synchronous neural activity that is primarily induced by the temporal character of the stimuli, such as common fate, though the spatial structure does augment the synchrony.