SPATIAL AND FUNCTIONAL ORGANIZATION OF LATERAL, FEEDFORWARD AND FEEDBACK PATHWAYS IN THE PRIMATE VISUAL CORTEX

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Classical receptive field (cRF) concepts and feedforward models of vision have traditionally been used to explain local perceptual effects, but cannot explain complex aspects of visual perception involving distant visual field locations, such as the perception of illusory or occluded contours. Neuronal correlates have been described for these perceptual effects, that require neurophysiological mechanisms enabling neurons to respond not only to stimulus features within a localized area of visual space (their cRF), but also to the context in which they appear (i.e. beyond their cRF).

Research in my lab is focused on identifying the neural circuitry underlying macaque visual cortex neurons responses to stimuli within and beyond their cRF, and ultimately visual perception. Long-range intra-areal horizontal (or lateral) connections and feedforward and feedback connections between different visual cortical areas are a prominent feature of visual cortical circuitry and inter-areal relationships whose roles remain poorly understood. To disentangle the relative roles of these connectional systems in visual processing, we have determined their spatial extent and functional organization and relate them to the spatial extent and functional properties of visual cortex neurons responses to stimuli within and beyond their cRF. The rationale behind these studies is that the spatial scale of each connectional system must be commensurate with the spatial scale of the specific neuronal response that it underlies. Furthermore, uncovering the functional specificity of a connectional system can reveal the kinds of functional interactions that the system may underlie.

We found that inter-areal feedforward connections underlie the spatial and tuning properties of V1 neurons responses to stimuli within their cRF. Intra-areal horizontal connections may underlie contrast-dependent spatial summation properties of cortical neurons, and lateral facilitation effects that may mediate the perceptual integration of local feature elements into coherent contours. Feedback connections from higher to lower order areas instead are likely to mediate the global-to-local computations underlying long-range contextual effects and possibly, contour integration at larger scales than horizontal connections. I will present a circuit model of how cortical neurons in primary visual cortex may integrate inputs from feedforward thalamic afferents, long-range intra-areal horizontal connections and feedback connections from higher visual areas.