Towards functional and anatomical mapping of every supragranular neuron in behaving mouse V1

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Task-dependent modulation of visual activity has been observed using electrophysiology and fMRI in primate thalamus and primary visual cortex (V1). However, effects appear less robust than in “higher order” visual areas. Why is this the case? One possibility is that the diversity of interdigitated functional circuits in V1 influence a broader range of behaviors than more specialized visual areas. In this way, the observed weaker mean correlation with specific behaviors observed in V1 may be due to sampling from neurons with different functional and anatomical connectivity. We suggest that concerted, task-specific modulation of neural activity in functionally and anatomically defined sub-circuits in V1 may exert a rapid and considerable influence on target areas and on behavioral outcome.

To test these hypotheses, we are developing a simple visual task in awake, head-fixed mice. Using in vivo two-photon microscopy, we will simultaneously monitor calcium activity in large populations of layer 2/3 neurons in mouse V1 during an orientation discrimination task. Sub-circuits will be defined by visual response properties, anatomical cell type (transgenic mice), and cell-cell correlations in spontaneous activity. In this way, we can assess the task-modulation of neural responses in identified assemblies, and their combined influence on behavioral responses. In the future, we hope to use optical techniques to directly and selectively perturb neural activity in task-modulated local assemblies of neurons during behavior.

In preliminary experiments, we have carried out two-photon imaging of visual responses in mouse V1 neurons during anesthesia and quiet waking. A subset of neurons were exquisitely direction selective, and virtually all neurons were driven by visual stimulation. This suggests a greater similarity between primary visual cortex in rodent and other mammalian visual systems than has been previously proposed.

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