From Connectivity to Function:

A Specific Micro-Circuit for Cortical Representation of Visual Scenery

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How is our visual environment represented and processed in the brain? In my lab, we seek answers to this fundamental question with a multi-scale approach combining two-photon imaging and electrophysiological recordings with computation model simulations. In this way, we can directly assess how neuronal response properties depend on the local network circuit. Connections between cortical neurons are not made randomly. Specific connections involving excitatory and inhibitory neurons have been measured both statistically and functionally in several areas of rodent neocortex. However, the precise composition of specific networks and the effect of specific connectivity on information processing in cortex remain in question, especially as a minority of synapses are likely to be made specifically. We found that specific excitatory connectivity can underlie amplification, decorrelation, competition and associative functions for cortex. Furthermore, our model simulations explain several observations of feature binding in visual cortex that we obtained using two-photon imaging of neuronal populations in mouse visual cortex. We also show that tuning for natural visual stimuli is independent of orientation preference, a likely consequence of specific connectivity. Our results suggest a population code, where the visual environment is dynamically represented in the activation of distinct functional sub-networks.