Spatial clustering of networks for processing of contextual information in mouse visual cortex

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Most behaviors are tied to vision, including identifying objects, guiding movements of body parts, navigating through the environment and social interactions. The faculties for generating perceptions and behaviors emerge from reciprocal communications between multiple specialized areas and local modules distributed across the cortex. To understand how this integration is achieved we need detailed knowledge of the underlying network structure of visual cortex at the mesoscopic and cellular level. For this purpose we have studied the functional partitioning in mouse visual cortex and the local and interareal feedforward and feedback connections that underlie the association of its parts. Because feedback input provides contextual information to pyramidal cell dendrites in layer 1 we were interested whether inputs from different thalamic and cortical sources to primary visual cortex (V1) are diffuse or selective for specific locations, marked either by strong or weak expression of type 2 muscarinic acetylcholine receptors in patches and interpatches, respectively. We found that thalamocortical inputs from the lateral geniculate nucleus preferentially terminated in patches, whereas inputs from the lateral posterior nucleus (LP) mainly contacted interpatches. Intracortical longrange feedback inputs from the higher visual areas LM, AL and RL to V1 terminated preferentially in patches, whereas inputs from areas PM and AM were more evenly distributed across patches and interpatches. Further, we have found that local horizontal connections within V1 have a daisy architecture, which shows stronger inputs to interpatches than to patches and span across large parts of the visual field representation. The results indicate that modulatory feedback and widespread horizontal connections are not diffuse but are preferentially targeted to specific modules with distinct tuning to high spatial frequency and high temporal frequency in patches and interpatches, respectively. Based on recent findings of the effects of locomotion on geniculocortical responses in mouse V1 (Roth et al., 2016) we suggest that feedback from LM, AL, and RL to V1 patches provides contextual information for interpreting the visual environment in the context of self-motion, which may correct path integration errors during navigation. In contrast, input from the LP thalamus and feedback from PM and AM to interpatches may deliver contextual information independent of the animal's own motion, which boosts the perceptual saliency of sensory inputs and improves referencing the position of an object relative to landmarks in space.