Adaptation dynamically alters cortical sensitivity to thalamic input precision

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There is a long-standing debate regarding whether cortical responses are primarily sculpted by feed-forward input from the thalamus, or tuned through numerous intra-cortical connections. Recently, it has been shown that precise timing of thalamic spikes can affect cortical response properties. We investigated the role of thalamic input precision in shaping cortical responses through a combination of recordings in the rat vibrissa system and modeling. Specifically, we recorded single unit activity in the ventral posterior medial (VPM) nucleus of the thalamus and in layer IV of the primary somatosensory cortex of anesthetized Sprague-Dawley rats in response to temporal patterns of vibrissa deflection. The observed cortical response properties were not simply inherited from the firing rate of VPM neurons, suggesting that intra-cortical interactions are required for shaping cortical responses. To investigate how the transformation between VPM and cortex occurs, we constructed a biophysical model of layer IV cortical circuitry driven by average recorded VPM responses. Simulations revealed that for transient deflection patterns the firing rate of cortical cells was sensitive to the precision of VPM inputs, and input precision was necessary for overcoming intra-cortical suppression. However, for repetitive periodic deflection patterns, the sensitivity of the cortical response to VPM input precision decreased throughout the stimulus train and was lost at steady-state. Taken together, these findings suggest that VPM input precision is an important determinant of cortical response magnitude for transient stimuli, but that adaptation dynamically alters cortical sensitivity to the temporal precision of VPM inputs.

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