Relating the diversity of interneuronal subtypes to their functional roles in development, homeostasis and sensory processing

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A circuit-level understanding of the cortex has long been sought, but only recently have improvements in genetic and imaging methods allowed systematic investigation of the roles of different interneuron classes. In particular, the chemical markers parvalbumin (PV), somatostatin (Sst) and vasoactive-intestinal peptide (VIP) have been found to divide interneurons into three non-overlapping subtypes that roughly correspond to previous, functionally defined subtypes (*1*). Studies show roles for these cells in a wide array of processes across different time scales, including development, homeostasis, and instantaneous sensory responses. We present an analysis investigating the involvement of these interneuron classes across all of these spatial and temporal scales, using a rate-based model of map development in primary visual cortex. The model includes the main anatomical and functional properties of the two most common GABAergic neuron types in the cortex, PV+ and Sst+ interneurons (*1*). PV+ neurons receive strong feedforward input, pro-

vide perisomatic inhibition, and are typically only weakly feature selective (*2*), while Sst+ neurons preferentially synapse on distal dendrites and mostly receive input from horizontal axons within layer 2/3 (*3*). Sst+ neurons are driven by facilitating synapses, and thus respond strongly only for high contrasts or large stimuli (*4*), giving them lower firing rates, stronger feature preference, and longer response latencies. The model allows us to link particular properties of these inhibitory neurons to specific functional roles, through parameter space exploration and lesion studies. The results show that the fast response of PV+ neurons makes them suited to balance feedforward excitation, while their broad activation helps sparsify cortical activity. This suggests a central role of PV+ neurons in map development and maintaining stability in the early sensory response. In contrast, Sst+ neurons are primarily recruited under high contrast or large stimuli, which results in a contrast-dependent switch in surround modulation from facilitation to suppression. Overall, our analysis suggests that PV+ neurons are central to organized development and balancing the instantaneous response, while Sst+ neurons integrate over larger temporal and spatial scales and mediate a range of surround modulation effects.

Introduction

References and Notes

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