Dendritic Excitability and Gain Control in Recurrent Cortical Microcircuits

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Abstract:

Layer 5 thick tufted pyramidal cells (TTCs) in the neocortex are particularly electrically complex, owing to their highly excitable dendrites. The interplay between dendritic nonlinearities and recurrent cortical microcircuit activity in shaping network response is largely unknown. We simulated detailed conductance-based models of TTCs forming recurrent microcircuits that were interconnected as found experimentally; the network was embedded in a realistic background synaptic activity. TTCs microcircuits significantly amplified brief thalamocortical inputs; this cortical gain was mediated by back-propagation activated N-methyl-d-aspartate depolarizations and dendritic back-propagation-activated Ca2+ spike firing, ignited by the coincidence of thalamic-activated somatic spike and local dendritic synaptic inputs, originating from the cortical microcircuit. Surprisingly, dendritic nonlinearities in TTCs microcircuits linearly multiplied thalamic inputs-amplifying them while maintaining input selectivity. Our findings indicate that dendritic nonlinearities are pivotal in controlling the gain and the computational functions of TTCs microcircuits, which serve as a dominant output source for the neocortex.

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