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Abstract:

Neocortical layer 5 (L5) pyramidal cells have at least two spike initiation zones: Na(+) -spikes are generated near the soma and Ca(2+)-spikes - at the apical dendritic tuft. These spikes interact with each other and serve as signals for synaptic plasticity. The present computational study explores the implications of having two spike-timing-dependent plasticity (STDP) signals in a neuron, each with its respective regional population of synaptic "pupils". In a detailed model of a L5 pyramidal neuron, competition emerges between synapses belonging to different regions, on top of the competition among synapses within each region, which characterizes the (STDP) mechanism. Inter-regional competition results in strengthening of one group of synapses, which ultimately dominates cell firing, at the expense of weakening synapses in other regions. This novel type of competition is inherent to dendrites with multiple regional signals for Hebbian plasticity. Surprisingly, such inter-regional competition exists even in a simplified model of two identical coupled compartments. We find that in a model of a L5 Pyramidal cell the different synaptic sub-populations "live in peace" when the induction of Ca(2+)-spikes requires the back-propagating action potential (BPAP). Thus, we suggest a new key role for the BPAP, namely to maintain the balance between synaptic efficacies throughout the dendritic tree, thereby sustaining the functional integrity of the entire neuron.

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