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Coincident excitatory and inhibitory spike-timing dependent plasticity potentiates pyramidal neurons

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Spike-timing dependent plasticity (STDP) has been demonstrated separately at both glutamatergic and GABAergic synapses, however the result of both of these synapses undergoing STDP simultaneously has not been examined. Here we investigate how simultaneous STDP of excitatory and inhibitory synapses onto CA1 pyramidal cells alters their probability and timing of spike generation, thus regulating the output of the hippocampus. Using a multicompartment model of a CA1 pyramidal neuron with excitatory and inhibitory synapses modeled onto the proximal dendrites, we demonstrate that when these synapses are modified by positive coincident (+10 ms) spike-timing dependent rules there is an increase in both the probability of generating an action potential and a decrease in the latency from synaptic input to spiking. Modifying both excitatory and inhibitory synapses with a negative coincident (-10 ms) spike-timing rules decreases pyramidal cell spiking less than if excitatory synapses were modified alone. When excitatory and inhibitory synapses undergo positive coincident spike-timing dependent synaptic plasticity, in the presence of a theta rhythm, there is a decrease in the interval between synaptic input and spiking which advances the spike forward on the theta cycle. Thus simultaneous modification of excitatory and inhibitory synapses alters the probability of spike generation and the precision of spike-timing within the hippocampus.