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Back propagating action potential and distant-dependent calcium signaling in CA1 pyramidal neurons

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CA1 hippocampal pyramidal neurons are involved in making associative memories. These neurons have an elaborate dendritic tree at which they receive thousand of synaptic inputs. These synapses are distributed across the whole tree, at different locations from the soma. At the soma, excitatory postsynaptic potentials (EPSP) generated at a distal synapse are attenuated to a larger degree compared to a distal synapse. Recently, Magee and Cook showed that the EPSP amplitude at the synapse is scaled with distance; distal synapses have larger EPSP amplitudes which compensates for the larger attenuation [1]. Effectively, this means that all synapses have the same effect on the soma, a phenomena called synaptic democracy.

However it is not known how this synaptic democracy is established. We hypothesize that synaptic plasticity is distant dependent, which could produce synaptic scaling. The back-propagating action potential, created by a somatic action potential, is thought to be essential for spike timing dependent plasticity (STDP). In STDP, the timing between the incoming signal at the synapse and the subsequent firing of the cell at the soma, determines the sign of plasticity at the synapse, resulting in long-term depression or long-term potentiation. Plasticity is mediated by the local calcium signal within a spine, induced by the back propagating action potential and synapse activation.

Here we investigate whether STDP is distant dependent by recording the local calcium signal in the spine and the dendrite at different synapse locations. This is done experimentally using two-photon live cell imaging with electrophysiology as well as computationally using a biophysical and morphological realistic CA1 pyramidal cell model implemented in NEURON.

References

1. Magee JC, Cook EP: **Somatic EPSP amplitude is independent of synapse location in hippocampal pyramidal neurons.** *Nat Neurosci* 2000, **3:**895-903.