

# Single neuron intra-burst activity as a carrier of spatiotemporal information

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Hippocampal CA1 pyramidal neurons have been shown to display both regular spiking as well as bursting activity in vivo. Using a refined version of a detailed biophysical model of a CA1 pyramidal neuron (Poirazi et al, Neuron 2003), we investigate the role of the laminated structure of the hippocampus on the firing pattern of these cells. In specific, we study the discharge of the model neuron during the burst and within the intra-burst period in order to find possible relation between two parameters: the Inter-Stimulus Interval and the Inter-Spike Interval. Towards this target, we use synaptic stimulation of two principal input pathways to the CA1 region, namely the Schaffer Collaterals and the Temporoammonic Pathway. The stimulation of the two afferents is separated by a time-delay ranging from 0-230 ms and splits the model neuron into two receiving layers. The aforementioned time-delay is called Inter-Stimulus Interval whereas Inter-Spike Interval is the distance between successive spikes within a burst event.

We find that for the specific stimulus protocol, the transition from regular spiking to bursting depends heavily on the temporal dispersion of the two stimulated pathways. Interestingly, for a particular time window, each Inter-Stimulus Interval is accurately mapped onto the average Inter-Spike Interval within the postsynaptic bursts. Furthermore, the distribution of Inter-Spike Intervals within bursts is strongly related to the arrangement of activated synapses. When synapses are activated in clusters within a few branches, the Inter-Spike Intervals are highly variable whereas a diffused arrangement appears to categorize the succession of spikes within bursts. Further analysis shows that predictability of Inter-Spike Intervals is optimized in the case of diffused synaptic arrangement and for short Inter-Stimulus Intervals. Our findings suggest that information about the spatio-temporal activation of synaptic contacts impinging on the CA1 pyramidal cell are reflected in the activity of the cell by means of a compact neural encoding, which embeds both spatial and temporal information in a bursting firing pattern.