Dynamically detuned oscillations account for rate and phase coding in the hippocampus

Mate Lengyel, Gatsby Unit, University College London

The firing pattern of principal cells in the hippocampus employs a characteristic double code: both firing rates and the exact timing of spikes relative to theta oscillation convey information about the spatial position of the animal. A model in which running speed-dependent input impinges the dendrite of place cells and modulates the frequency of membrane potential oscillations is proposed. We show that an interaction between intradendritic oscillations and phasic somatic hyperpolarization accounts for salient properties and even fine details of pyramidal cell firing in the behaving animal. Dynamics of dendritic spiking in a simplified biophysical model are further analyzed in response to theta modulated inputs and shown to contribute significantly to the robustness of the proposed mechanism. Introducing a speed-dependent component also to somatic input reproduces recent experimental findings of apparent decoupling of the rate and phase code.

Time permitting, I will also briefly describe ongoing research aiming at deriving optimal rate- and phase-based neural network dynamics in an auto-associative memory framework of hippocampal function. Preliminary results suggest that hippocampal dynamics may be ideally suited for memory retrieval. Part of this work was supported by the Gatsby Charitable Foundation.