SFB 1315
Mechanisms and Disturbances in Memory Consolidation:
From synapses to systems

Tuesday

MAR 11, 2025
4:00 pm

BCCN Lecture Hall
Philippstraße 13/Haus 6
10115 Berlin
Meeting-ID: 775 491 0236
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SFB 1315 LECTURE SERIES 2025

ADAPTIVE DYNAMICS OF SINGLE NEURONS IN SMALL NETWORKS

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A hallmark of neuronal network activity is the selective recruitment of neurons into active ensembles, which form transiently stable patterns of activity. In the mammalian hippocampus, the activation of such neuronal ensembles is orchestrated by network oscillations. A central question is how individual neurons are selected for participation in these patterns of coactivity. The prevailing concept is that activation of specific neurons results from the convergence and use-dependent plasticity of excitatory synapses. In this view, the strong rhythmic perisomatic inhibition during network oscillations provides a global gain control mechanism for all local neurons, and a temporal scaffold for the embedded spatiotemporal activity patterns.

According to the textbook view, pyramidal neurons integrate multiple synaptic inputs to their dendrites at the soma, from where the axon originates and generate action potentials whenever excitation is strong enough to reach threshold at the axon initial segment. Recent work, however, has revealed that in ~50% of hippocampal pyramidal cells the axon emerges from a basal dendrite. The resulting asymmetry privileges inputs to the axon-carrying dendrite which may escape control by somatic inhibition and, hence, play a special role in activating such neurons.

We studied this potential mechanism during ripple oscillations in the rodent hippocampus, a pattern known to activate highly specific neuronal ensembles and to recruit pronounced perisomatic inhibition. In awake, head-fixed mice, we found that CA1 pyramidal neurons with a dendritic axon origin displayed an ~4-fold higher firing frequency during ripple oscillations compared to neurons with somatic axon origin. This difference was absent outside ripples. Extra- and intracellular recordings in mousbrain slices and computer simulations led us to hypothesize that the axon forms a functional unit together with the axon-carrying dendrite. Indeed, evidence from experiments and computer simulations show that excitatory input to axon-carrying dendrites readily triggers action potentials even during strong perisomatic inhibition. In contrast, other dendrites are uncoupled from the axon by perisomatic inhibition, preventing their input to trigger action potentials.

The inhibition-dependent recruitment of morphologically distinct pyramidal cells provides a new mechanism of state-dependent neuronal recruitment. Perisomatic inhibition may, thus, not only be a global gain control, but a dynamic gate control for the activation of ensembles from different populations of principal cells. Moreover, given the abundance of similar axon morphologies in other cortical and subcortical areas of the vertebrate brain, it may well be that the selection of active neurons by their axon origin is a widespread principle.

Dr. Both's lecture is part of Brain Awareness Week Berlin (a cooperation with BCCN Berlin, the Einstein Center for Neurosciences Berlin, and the NeuroCure Cluster of Excellence) www.brainawareness.org

This talk is hosted by Marina Mikhaylova (project leader A03, A10)

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