S29.01

Rhythms and spatial representation in the entorhinal-hippocampal network

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Brain rhythms reflect periodically synchronized electrical activity across groups of neurons and are thought to facilitate neuronal communication across brain regions. Gamma is a particular rhythm type that occurs throughout many regions of the brain and has been linked to functions such as attention and memory. The hippocampus, a key brain region for memory, is believed to exhibit two distinct subtypes of gamma rhythms, termed slow and fast gamma. In this talk, evidence will be presented that supports the hypothesis that slow and fast gamma rhythms serve different functions in the hippocampal network. Our results show that the principal neurons of the hippocampus, "place cells", code spatial information differently during slow and fast gamma. Also, new unpublished results suggest that slow and fast gamma rhythms promote different memory operations.

Keywords: Hippocampus, Place cells, Gamma rhythms, Memory

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S29.02

Asynchronous irregular states during wakefulness, and Up/Down states during sleep: How to make sense of this activity?

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In the awake adult mammalian cerebral cortex, neuronal activity is sustained, asynchronous and irregular, but how such complex activity states support information processing still remains mysterious. To address this question, we first review multielectrode recordings in awake human and monkey that reveal the degree of regularity and asynchronicity, and the balance between excitatory and inhibitory populations. In addition, intracellular recordings measure the amount of excitatory and inhibitory conductances in single neurons. These data can be used to constrain computational models of the awake cerebral cortex. Second, the extracellular recordings are used to characterize the unit activity during slow-wave sleep, which consists of "Up" and "Down" states. The activity during Up states is statistically similar to that of wakefulness, suggesting that Up-Down state dynamics reflect a replay of awake experiences, separated by silences. To make sense of this activity, we show that simple spike-based plasticity rules, such as STDP, do not lead to robust synaptic changes. With the addition of a floating threshold (mSTDP), synaptic weight changes are robust to the sustained irregular activity of wakefulness, but can be modified during the Up-Down state dynamics of sleep. This suggests that the Up/Down state dynamics during sleep, combined with a floating threshold for plasticity, is a plausible mechanism for sleep-specific memory consolidation.

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Keywords: Plasticity, Awake, Sleep, Network, Model

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S29.03

Hippocampus as a multisensory association circuit

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The hippocampus has been extensively investigated in the context of learning and spatial or episodic memory. Despite tremendous progress, there are several major paradoxes about hippocampal function. To address these, we have been investigating hippocampal function using virtual reality and computational modeling. Based on our findings we suggest a novel hypothesis, that the hippocampus acts as a hierarchical, multisensory association circuit. The nature of multisensory associations and the internal dynamics would result in the diverse range of hippocampal responses and functions. This computational hypothesis can not only explain our findings but has the potential to resolve many long standing puzzles.

Keywords: Hippocampus, Place cell, Head direction, Navigation, Virtual reality

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S29.04

Degeneracy in robust spatial encoding

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Degeneracy, the ability of disparate constituent elements to yield similar function, is a ubiquitous phenomenon that imparts robustness to biological processes across different scales spanning gene interactions to behavioral repertoires. How does the framework of degeneracy assimilate into an encoding system where the ability to change is an essential ingredient for storing new incoming information? Could degeneracy maintain the balance between the apparently contradictory goals of the need to change for encoding and the need to resist change towards maintaining homeostasis? In this talk, a case will be built for the existence of such degeneracy in spatial encoding in the rodent hippocampal formation. Although work from the laboratory has accumulated experimental and computational lines of evidence spanning several cell types and networks within the hippocampal formation, this talk will focus on the rate and phase codes in CA1 place cells. Conceptually, lines of evidence for the expression of ion channel degeneracy in the following will be presented: (i) the concomitant emergence of several intraneuronal functional maps along with sharp-tuning of hippocampal place cells, endowed with dispersed synaptic localization profiles in multiple neuronal morphologies; and (ii) the concomitant emergence of intrinsic physiological signatures and efficient phase coding in hippocampal place cells.

Keywords: Place cells, Phase code, Rate code, Degeneracy, Efficient coding

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