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Predictive grid representation in the medial entorhinal cortex

演者: **藤澤 茂義 先生**

理化学研究所 脳神経科学研究センター

時空間認知神経生理学研究チーム チームリーダー

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Abstract

Although the entorhinal cortex plays a fundamental role in spatial navigation, it remains unclear how the entorhinal grid system supports the planning of future travel paths. Here, we investigated the neuronal representation of predictive spatial information in the medial entorhinal cortex (MEC). We performed large-scale extracellular recordings from the MEC and hippocampal CA1 of rats during goal-directed behavior in a two-dimensional open field. In this task, rats were required to move back and forth between the two water reward ports, whose positions were changed every block of trials. In the MEC, we found a set of neurons that had a grid representation for future projected positions, which we termed predictive grid cells. These predictive grid cells represented future spatial information by shifting their grid fields against the direction of travel. Importantly, predictive grid cells were robustly phase-modulated by theta oscillations referenced to the CA1 pyramidal cell layer, and they had unique phase preferences compared to the standard grid cells. Bayesian decoding analysis revealed that neuronal assemblies of predictive and standard grid cells organized a sequence representation of the rat's trajectory from current to future positions across theta cycles. We also analyzed the functional connectivity between the predictive grid cells and CA1 place cells. We found that the probability of spike transmission from predictive grid cells to CA1 place cells was higher than from CA1 place cells to predictive grid cells, suggesting that predictive grid cells in the MEC may convey future spatial information to the CA1. We hypothesize that these predictive grid cells underlie the mechanisms of forward planning in spatial navigation in the circuitry of the entorhinal cortex and hippocampus.

References

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Organizer: Tetsufumi Ito (RCIBS/Systems Function & Morphology Lab) (Ext,7212)