Value-dependent Play and Replay of Hippocampal Place Cells

JUNG Min Whan

IBS/KAIST

The hippocampus has long been considered as a computational area where cognitive variables related to spatial navigation and episodic memory are computed and represented, whereas value-related signals are thought to be processed elsewhere in the brain such as the basal ganglia and orbitofrontal cortex. Contrary to this traditional view, we found strong value signals in the CA1 region of the hippocampus in rats performing a dynamic foraging task. Value signals are substantially weaker in CA3 and subiculum, which are major input and output structures of CA1, respectively, and selective inactivation of CA1, but not dentate gyrus, CA2 or CA3, impaired value learning in a dynamic foraging task. These results suggest CA1 may play a particularly important role in valuation among hippocampal subregions. We also found reward-dependent replays of CA1 place cell sequences during awake immobility in a spatial sequence memory task. Reward enhances the rate of reverse replays, but it increases the fidelity of forward replays for recently-travelled as well as other alternative trajectories heading toward a rewarding location. This suggests roles of forward and reverse replays in reinforcing representations for all potential rewarding trajectories. We also found more faithful reactivation of future than past rewarding trajectories in forward replays, which suggests a role of forward replays in preferentially reinforcing representations for high-value trajectories. We propose a new model for hippocampal function—the simulation-selection model—based on these new findings.