Probing the Neural Code for Spatial Memories

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People travel from place to place on a daily basis. Spatial navigation is a fundamental survival skill in humans and animals. How does the brain encode and store information about places and spatial trajectories? Neurons in the brain are believed to use spikes to encode information and we know that two brain areas, the hippocampus and neocortex, are critical for spatial navigation. To study the neural mechanisms of spatial memory, we use the tetrode recording technique to simultaneously monitor spikes of up to hundreds of neurons from the hippocampus and neocortex in rats or mice that are running mazes. We found that two sets of neural codes for spatial memories exist in the brain. The one in the hippocampus forms quickly and is believed to serve as a temporary storage of spatial memories, whereas the other in the neocortex changes slowly, but for the long-term storage. The transformation between the temporary and the long-term memories may require “offline” memory consolidation during sleep or rest, through the reactivation of both neural codes. In mice with Alzheimer’s disease-like phenotypes, the hippocampal spatial memory code becomes rigid and inflexible when external environments change from one to another. This line of research have begun to elucidate how the cells and neural circuits in the brain form, consolidate, and store spatial memories during active behavior and during offline sleep, and how they break down in neurological and psychiatric diseases.