

Organization of multiple spatial representations in the discharge of hippocampal place cells.

Animals, including humans, must process and organize vast amounts of information that impinge on their senses. An organism must decide which subset of incoming information is relevant at a particular moment, and be able to activate representations and memories at the appropriate time. We studied how multiple representations are organized in the discharge of ensembles of place cells in the hippocampus. For this we created a double place avoidance task in which a rat had to process two types of spatial information that were concurrently relevant. A rat was placed on a slowly rotating (1 rpm) circular arena (82 cm in diameter) and had to avoid two shock zones. One shock zone was defined by distal landmarks in the room, and the other shock zone was defined by local landmarks on the arena itself. To perform the task the rat had to process spatial information about its location in the room and, at the same time, information about its position on the arena. While animals were performing this task we recorded the activity from ensembles of hippocampal CA1 neurons.

We observed that the two different representations were organized in the hippocampal discharge by activating one representation at a time and dynamically switching back and forth between them. This switching occurred on a timescale of hundreds of milliseconds to seconds and reflected the current behavioral needs of the animal. We named this mechanism 'dynamic grouping', as the activity of neurons which process the same type of information is dynamically grouped together in time. In a related study, we observed that a similar mechanism organizes the activation of the representations related to the two spatial tasks which occurred in the animal during different experimental sessions. In this case, the hippocampal firing pattern related to the memory of the previously performed task was intermittently reactivated while an animal was performing a different task.

In summary, we described the dynamic grouping of activity of hippocampal place cells as a mechanism that organizes different spatial representations and different spatial memories on a timescale of hundreds of milliseconds and seconds.