Space and time in the entorhinal cortex

Edvard Moser[1]

[1]Kavli Institute for Systems Neuroscience, Trondheim, Norway

The medial entorhinal cortex is part of a neural system for mapping of self-location. One of the first components to be detected in this internal map was the grid cell. Grid cells fire when animals are at locations that tile the environment in a periodic hexagonal pattern. Today the entorhinal space circuit is known to embody a spectrum of cell types, including also head-direction cells, speed cells, and border cells. These cells were discovered in simple featureless environments. In this lecture, I will first show that when spatial behavior is tested in environments with salient objects or landmarks, a hitherto undescribed subset of medial entorhinal cells fires in a vector-like manner at distinct distances and directions from objects in the recording enclosure, irrespective of where in the enclosure the object is located, and irrespective of the identity of the object. In the second part, I will switch to neural representation of time. I will show that temporal information is robustly encoded across scales from seconds to hours within the overall population state in lateral entorhinal cortex. Similarly pronounced encoding of time is not present in medial entorhinal cortex or hippocampal areas. When animals' experiences are constrained to become similar across repeated task trials, the encoding of temporal flow across trials is reduced while encoding of time relative to trial start is improved. This task-dependent representation of time may be integrated with spatial inputs from MEC in the hippocampus, allowing the hippocampus to store a unified representation of what/where/when.