366.25: An evidence of a hierarchical representation of object-place memory based on theta phase coding: a computational model-human experiment combined analysis

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Object-place association memory in human is known to be critically managed by the hippocampus. It suggests the importance of instantaneous network formation enabling to operate multiple information contents in the hippocampus, while its neural mechanism is an open question. The authors have proposed a cortico-hippocampal network model of the memory task (Sato and Yamaguchi, Hippocampus 2005). In this model, a hippocampal neural dynamics, "theta phase precession", observed in rat hippocampus was applied to cortico-hippocamal system with a randomly saccadic visual input sequence through central and peripheral visual pathways. A saccadic sequence of visual information is compressed and encoded in phase of every theta cycle in the entorhinal cortex. Then, theta phase coding of temporal sequences characterizes the synaptic plasticity in the CA3. Computer simulation with several second saccades demonstrated a content specific network structure in the resultant associative memory. Object and scenes are differentially represented in a hierarchical network of asymmetric connections, while its functional relevance is still unclear.
In this paper, we combine the computational model and human object-place association memory experiments to elucidate the computational theory of memory formation and recall. 350 trials of human eye movement data during 8s encoding of four object-place associations (from eleven subjects) were used in computer simulation of the model and the resultant network structure of the model and recall performance of human experiments were statistically analyzed. Scalp EEG in memory encoding period exhibited theta power increase correlated with recall performance in agreement with our hypothesis.
Our computational model study demonstrated that hierarchical network of asymmetric connections among CA3 units are robustly generated under experimentally obtained human saccadic sequences and that the correct recall in the model significantly correlated to a measure of a hierarchy structure. Importantly, the hierarchy measures obtained in the model were also significantly correlated with a human correct rate in the experiment. These results indicate the contribution of theta phase coding in a formation of object-place association memory and the functional significance of resultant hierarchical network in memory recall.

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