Abstract View

A HIERARCHICAL REPRESENTATION OF OBJECT--PLACE MEMORY OBTAINED BY THETA PHASE CODING IN THE HIPPOCAMPUS: A COMPUTATIONAL STUDY

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It is known that object-place association memory is maintained by the hippocampus. The ability of instantaneous memory formation of multiple objects with spatial configuration from visual scenes has not been clarified as neural mechanisms. The authors reported that neural dynamics known as "theta phase precession" in freely running rat hippocampus and spike timing dependent plasticity can be applied to such a memory formation task (Sato & Yamaguchi, 2003). They introduced a randomly saccadic visual input sequence with central and peripheral vision in the hippocampus model. Theta phase coding of the sequence compressed into every theta cycle results in associative memory formation in the CA3. Interestingly a layer for objects and a layer for scenes were separately organized, while their details were unknown. In this paper, by using a simplified computational model, the network structure and its information representation were elucidated. Our analyses demonstrate that the resultant associative memory network has a multi layered structure consisting of a layer of object units and a number of layers for scene units. Each scene layer has units with the same inclusion level with respect to the concurrent activation with an object ensemble. By assuming a node as a group of scene units with common inclusion relation, nodes are symmetrically connected within each layer and asymmetrically connected between different layers. Each layer represents environmental geometry in a proper spatial scale. Asymmetric connections appear between layers representing the depth of hierarchy in a multiple-scale representation. Object units are linked at the bottom of this hierarchical structure. Such hierarchical representation of object and space was found to emerge regardless details of parameters in the model. These results together with further memory retrieval experiments indicate a crucial role of theta phase coding and resultant hierarchical representation in an environmental map formation based on egocentric information in the hippocampus.

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