A Grid/Place Cell Model of Episodic Memory and Spatial Navigation in the Medial Temporal Lobe

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Submitter David Huber

Affiliation University of Massachusetts, Amherst

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Presentation Abstract Summary The precise spatial tuning of hippocampal place cells and entorhinal grid cells suggest that the medial temporal lobe (MTL) plays a primary role in spatial navigation. At the same time, neuropsychological studies find that the MTL supports the formation of episodic memories. Reconciling these results, we present a neural network model that produces grid cell and place cell representations from episodic memories in a high dimensional feature space. A representation of a new episode (i.e., a place cell) is created when the current situation (including location) is sufficiently novel. Online consolidation adjusts memory representations such that the current (perceived) state of the world is well-enclosed by surrounding memories. When simulating a rat in an arena devoid of landmarks, there are only three dimensions of variation during an episode of navigation: X/Y, which reflect border cells, and head direction. This results in a three-dimensional face-centered close packing of memories within the high dimensional space. Owing to strong hippocampal feedback, head direction cells in entorhinal cortex exhibit a widely spaced grid pattern while cells representing features ubiquitous in the navigation context (e.g., odor, surface texture, etc.) exhibit a tightly spaced grid, reflecting a 2D projection of the 3D memories.

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Co-author Information

* Presenting Author

First Name	Last Name	Affiliation	E-mail
David *	Huber *	University of Massachusetts, Amherst	dehuber@psych.umass.edu
Trygve	Solstad	Norwegian University of Science and Technology	trygve.solstad@ntnu.no

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