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Presentation Abstract

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Presentation Title: Place cell rate remapping in the hippocampus by CA3 collaterals

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Authors: *T. SOLSTAD[1,2,3], H. YOUSIF[2], T. J. SEJNOWSKI[1];
[1]CNL-S / Salk Inst., La Jolla, CA; [2]Univ. of California San Diego, San Diego, CA; [3]Norwegian Univ. of Sci. and Technol., Trondheim, Norway

Abstract: Hippocampal 'place cells' have spatial receptive fields whose mean firing rate depends on contextual features of the environment, a phenomenon called rate remapping. Experiments morphing one familiar environment into another have concluded that attractor dynamics influences receptive field position but not firing rate, suggesting the existence of spatial but not contextual attractors. How are the firing rates of place cells modulated by context in area CA3?
We investigated a network model of CA3 place fields in which each position in the environment was represented by a CA3 cell assembly. Context- and distance-dependent modulation of cell assemblies was implemented by collateral connections between cell assemblies, with strengths influenced by Hebbian synaptic plasticity. The network received two streams of input: A contextual input carried discrete activity patterns without spatial modulation, mimicking environmental features, derived from lateral entorhinal cortex , and a spatial input carried information about the rat's position in the environment, arising from medial entorhinal cortex and other visuo-spatial areas projecting to the hippocampus.
We found that: (1) For ambiguous spatial input, the structure of the recurrent connections determined whether rate- (contextual) or global- (spatial) remapping was induced when the contextual input switched between two environments. This suggests that the spatial component of CA3-to-CA3 connections defines the spatial map corresponding to a particular context, and that CA3 can induce global remapping even in the absence of precise spatial input, consistent with recent findings (Koenig et al., 2011); (2) The context-dependent component of the collateral weights resulted in discrete attractor basins for place field rates, visible when the contextual input was homogeneous or not a combination of the

two previously stored patterns; (3) Population activity underwent sharp transitions between end shapes of a morph sequence in the global remapping regime but smooth transitions in the rate remapping regime for sufficiently strong contextual input; (4) Hysteresis was observed for strong recurrent collaterals, a signature of attractor dynamics and a possible substrate for short-term working memory.
We conclude that CA3 attractor dynamics may significantly influence place cell representations and propose new experiments to test this prediction.

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