



Presentation Abstract

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Presentation Title: Distinct CA3 attractor states revealed by mean field modeling

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Topic: ++F.02.ff. Learning and memory: Cortical and hippocampal circuits

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Abstract: Activity patterns of hippocampal place cells and entorhinal grid cells correlate strongly with the physical location of an animal in its environment (O'Keefe 1978, Fyhn et al 2004). A major class of models based on the dynamics of continuous attractor networks has been proposed to describe the spatial selectivity of these cells (Tsodyks and Sejnowski 1995, Samsonovich and McNaughton 1997). However, place cell activity has also been shown to deviate dramatically from strictly spatial firing (Fenton 1998, Allan 2012). To investigate whether the spatial mapping hypothesis of the hippocampus is consistent with the modulated responses of hippocampal cells to environmental morphing procedures (Leutgeb 2005, Colgin 2010), we developed an attractor network model of area CA3 in which network architecture facilitates both spatial selectivity and contextual modulation. The network was modeled using the Wilson-Cowan formalism with a combination of spatial and localized Hopfield connectivity structures: Within cell assemblies with similar place field positions, multiple statistically independent representations of non-spatial information about the environment were stored, while connection strength between different cell assemblies decayed as a function of distance between the cells' preferred positions. Individual cells were found to exhibit both spatial selectivity and overly dispersive firing rate variability signalling encoding of non-spatial information. In the mean field approximation, we analytically computed the network phase diagram and found three distinct network regimes whose activation rates depended on the degree of correlation, the distributions of assembly membership and the relative

strengths of recurrent activity/entorhinal input. These modes generated statistical signatures matching i) purely feedforward networks, ii) Hopfield-like attractor networks, or iii) ‘quasi-spatial’ networks that could simultaneously express multiple attractors. Simulations of single cell dynamics in a morph experiment showed a wide range of transitioning behaviors in accordance with experimental data; signatures of transitions between network states matching both global and rate remapping statistics could be reliably seen in the correlation structure of neural activity at intermediate timescales. Finally, the model predicts that the different modes of CA3 assembly dynamics can be revealed by a novel large scale temporal analysis of CA3 unit recordings.

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