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Presentation Abstract

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| Program#/Poster#: | 94.05/III5 |
| Presentation Title: | Grid cell responses in 1D environments are consistent with 2D continuous attractor dynamics |
| Location: | Halls B-H |
| Presentation time: | Saturday, Nov 09, 2013, 1:00 PM - 2:00 PM |
| Topic: | ++F.02.ff. Learning and memory: Cortical and hippocampal circuits |

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Abstract: Grid cells in 2D environments show evidence of low-dimensional continuous attractor dynamics, as shown through analysis of their population responses [1]. However, unlike in 2D environments, the grid response in 1D is non-periodic. Moreover, the average peak spacing is 5-6 times larger than in 2D, and we occasionally observe gradual drifts of some activity peaks relative to others, in individual cells. These observations raise the question of whether the grid cell system maintains or switches dynamical regimes during navigation in different environments under varying sensory conditions (e.g. 1D versus 2D and actual versus virtual reality). The dynamical regime of a system constrains what computations it performs.

To answer the question, we examined multiple simultaneously recorded cells in 2D environments and 1D virtual tracks [2]. The essential prediction of 2D attractor dynamics for grid cells is that all cells' responses are determined by rigidly shifting a stable 2D population activity pattern over the cortical sheet, and thus cell pairs must exhibit fixed activity relationships (relative spatial phase), regardless of any other changes.

We establish three results: First, cell-cell correlations remain stable both when all activity peaks of all cells are stable and when there is a drift in a fraction of the activity peaks of individual cells. Second, the Fourier power spectra of the cells' 1D responses are highly correlated across trials, exactly as expected for rigid

translations of a 2D population pattern along some 1D trajectory. Finally, the 1D firing rates are well-fit by parallel trajectories through the 2D pattern, with a predicted 2D phase separation that closely matches the actual relative phases of the cells when measured in 2D environments. These results constitute strong evidence that 2D continuous attractor dynamics underlies the grid cell response, across 1D and 2D environments and varying sensory conditions.

[1] Yoon, K., Buice, M., Barry, C., Hayman, R., Burgess, N. & Fiete, I. Evidence of low-dimensional continuous attractor dynamics in grid cells. *Nature Neuroscience* (accepted, May 2013).
[2] Domnisoru, C., Kinkhabwala, A. A. & Tank, D. W. Membrane potential dynamics of grid cells. *Nature* **495**, 199-204 (2013)

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GRID CELLS

SPATIAL MEMORY

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