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Presentation Abstract

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Presentation Title:	1D grid fields are slices of a 2D hexagonal lattice
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Authors: ***S. J. LEWALLEN**[1], K. YOON[4], A. A. KINKHABWALA[2], C. DOMNISORU[2], D. W. TANK[3], I. FIETE[5];
[1]Mathematics, [2]Mol Bio, [3]Mol Bio / PNI, Princeton Univ., Princeton, NJ; [4]Ctr. for Learning and Memory, The Univ. of Texas at Austin, Austin, TX; [5]Ctr. for Learning and Memory, The university of texas at austin, Austin, TX

Abstract: During the exploration of a 2D environment such as a circular or square arena, grid cells in the medial entorhinal cortex display a strikingly periodic firing pattern, with activity peaks at the vertices of a triangular lattice tiling 2D space. When recorded in 1D environments such as linear tracks, grid cells continue to display spatially stable firing rate peaks; however, these peaks are not periodically spaced [1], and their amplitudes are more variable than their 2D counterparts. What is the underlying structure of these 1D grid cell patterns, and how are they related to grid cell activity in 2D?

Here, we investigate the hypothesis that grid cell responses in 1D are linear slices of a 2D triangular lattice. Although distinct slices of the same lattice can appear quite different, they share a rigid structure, expressible in terms of the peaks in their Fourier spectra. Employing Fourier analysis as well as a more direct, exhaustive-search method, we show that many 1D grid cell responses clearly demonstrate the special structure of a 1D slice. Furthermore, our analysis shows that the 1D firing patterns of grid cells recorded on the same tetrode are almost always parallel slices through a single lattice, even when these firing patterns appear dissimilar. This is precisely what is observed in 2D, where grid cells recorded on the same tetrode tend to have lattices with very similar orientation and spacing, differing only by a translation. A final piece of evidence that 1D grid cell activity is a slice of 2D involves intracellular recordings [2]. We find examples of

1D recordings where the predicted slice just barely misses the 2D firing field, and the subthreshold depolarization of the membrane potential corresponding to that field can still be measured in intracellular recordings [2], in the correct location predicted by the geometry of the slice.

Our finding that 1D and 2D grid patterns seem to share the same mechanism has several implications for the general analysis of 1D grid cell recordings: for example, we show that within-track irregularities in recordings from [1], as well as the frequently observed differences in field locations during forward and backward traversals of linear tracks, can be explained in the context of the remapping of underlying 2D grids. In summary, our method gives the first strong evidence that the striking hexagonal firing patterns of 2D grid cells are maintained in 1D environments.

[1] V, Brun,et al. Progressive increase in grid scale from dorsal to ventral medial entorhinal cortex. Hippocampus, 18(12):1200-1212, 2008.

[2] C. Domnisoru et al. Membrane potential dynamics of grid cells. Nature, 495(7440):199-204, 2013.

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SPATIAL MEMORY

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