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Presentation Abstract

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| Title: | Assessing the role of feedback in spatially patterned grid cell responses |
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Abstract: We analyze the spike trains of multiple simultaneously recorded grid cells obtained in different conditions, to help determine the role of recurrent network feedback in generating grid responses.
An important class of models of grid cell activity is based on low-dimensional continuous attractor dynamics arising from recurrent connections within the grid system[1]. A necessary prediction of these models is that the strong recurrent connections force the grid responses of different cells to maintain fixed relative spatial phases over long periods of time, even if the response patterns of each neuron change. The observation that grid cells maintain their relative spatial phase relationships across different familiar environments[2] supports the presence of recurrent connections, but does not rule out the possibility that these relationships persist due to feed-forward input.
We analyze the stability of pairwise neural correlations for experiments in which the spatial responses of single neurons change over time. The first such experiment involves resizing of a familiar enclosure, with the result that spatial grid responses rescale along the resized dimension[3]. We show that the relative spatial phase of firing between pairs of cells remains stable over time even as the absolute spatial phase of firing in these same cells changes greatly through rescaling. This result is again consistent with recurrent connectivity, but it remains possible that common

external sensory cues (e.g. border information arriving from boundary cells) somehow register the rescaled grids of all cells to display the same relative phases as before rescaling.
In an attempt to address this, we analyze responses from animals' first exposure to novel environments. Grid firing becomes more noisy and the spatial firing pattern expands, then relaxes back to the periodicity seen in familiar enclosures[4]. During the relaxation, external sensory cues are static and thus likely not responsible for the changing grid responses. We analyze whether the constant phase relationships seen across familiar environments are present from first exposure or develop over time.
Finally, we illustrate how to optimize non-linear parametric models of neural response to predict grid cell spikes. The aim is to obtain the key determinants of grid cell firing, including animal location, velocity modulation, LFP input, neural adaptation, and recurrent feedback in a Bayesian framework, and thus assess network contributions to grid cell activity.
1. Fuhs & Touretzky (2006) J. Neuroscience 26(16), 4266-4276
2. Fyhn et al. (2007) Nature 446, 190-194
3. Barry et al. (2007) Nature Neuroscience 10, 682-684
4. Barry et al. (2009) SfN

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