ORAL PRESENTATION

How good is grid coding versus place coding for navigation using noisy, spiking neurons?

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Our understanding of how the brain encodes navigation through space underwent a revolution with the remarkable discovery of grid cells in the medial entorhinal cortex (MEC) of rodents [3]. A grid cell builds a hexagonal lattice representation of physical space, such that the cell fires whenever the rodent moves through a lattice point. In contrast, place cells in the hippocampus proper fire only at a single, specific location in space.

Different place cells encode different spatial locations, while different grid cells exhibit different lattice spacings, orientations, and phases. At the level of a single neuron, the multiple firing fields of a grid cell lead to an inherent ambiguity in the position estimate. Hence, for both codes precise information about position can only be gained from a population of grid and place cells respectively. We will present two different interpretations of the grid population code, one as an effective way of subdividing space with a high resolution and one based on modular arithmetic, similar to Fiete et.al. [2]. For a clarification of these concepts look at Figs 1 and 2 and in the appendix. We furthermore argue that the modular arithmetic interpretation is lacking robustness in both: capacity and resolution.

After these interpretations we set out to investigate the spatial resolution of the place code and the grid code on a limited, one-dimensional space with a finite amount of cells and families of tuning curves. Therefore, we built a stochastic population coding model as in Bethge [1]. The family of tuning curves convert the position into firing rates for statistically independent Poisson neurons. To compare the two coding schemes we calculate the maximum likelihood position estimate and compute the mean square error of the population code. We believe that the grid and place code should enable real-time readout of the rat's position while it is
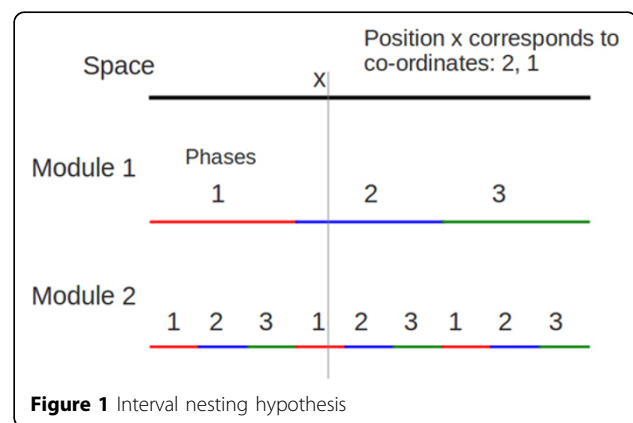
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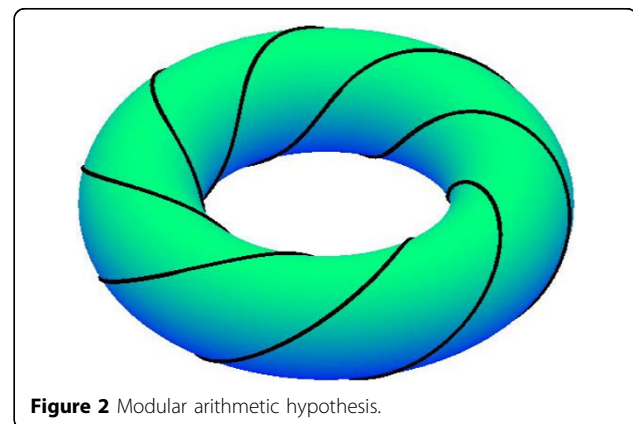
Figure 1 Interval nesting hypothesis

Figure 2 Modular arithmetic hypothesis.

moving. For this reason, we have to consider short decoding times and hence, since Fisher information methods based on the Cramér Rao bound fail to estimate the mean error in such cases [1], we make use of Monte Carlo integration methods.

Under the condition of noisy, spiking neurons, we demonstrate that the grid code, if it is organized as in the interval nesting hypothesis outperforms the place

code for any tuning width. On the other hand, if it is organized as in the modular arithmetic hypothesis, i.e. spatial periods that are far shorter than the length of space the grid code has a lower distortion than the best place codes.

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