Correlation functions of hippocampal place cells in open field environments

Mauro M. Monsalve-Mercado, Christian Leibold
Department Biology II
Ludwig-Maximilians-Universitaet
Munich, Germany
e-mail: monsalve@bio.lmu.de

Hippocampal place cells' spiking patterns have been extensively studied on linear tracks. The direct correspondence between space and time in this case, provides an accesible framework on which to study temporal coding strategies, with implications for spatial navigation and memory formation. On the population level, the precise temporal relationship between spiking neurons is readily encoded in the correlation functions, and in the linear track case, can be linked in a straightforward manner to spatial properties characterizing the place fields by means of phase precession. There is, however, little work concerning the temporal structure in an open field exploratory task. Indeed, undersampling of the area shared among two place fields hinders a clear observation of the associated correlation function.

In this work, we develop an analytical framework in which to explore the temporal relationship between two dimensional place fields, which are modeled to undergo phase precession and theta modulation. As our main result, we provide a concise mathematical description of the correlation function, and highlight its connection to spatial parameters shaping the place fields. We contrast our findings with a numerical simulation of place cell activity following a random walk on a circular arena, whose firing patterns arise form a Poisson point process that generate noisy spike patterns.

Keywords: correlation functions, spatial navigation, place fields