BMC Neuroscience

Poster presentation

The Type II phase resetting curve is optimal for noise-induced synchrony: a mathematical proof

Aushra Abouzeid* and Bard Ermentrout

Address: Department of Mathematics, University of Pittsburgh, Pittsburgh, PA 15260, USA

Email: Aushra Abouzeid* - aua1@pitt.edu

* Corresponding author

from Seventeenth Annual Computational Neuroscience Meeting: CNS*2008
Portland, OR, USA. 19–24 July 2008

Published: 11 July 2008

BMC Neuroscience 2008, **9**(Suppl 1):P144 doi:10.1186/1471-2202-9-S1-P144

This abstract is available from: http://www.biomedcentral.com/1471-2202/9/S1/P144

The phase resetting curve (PRC) describes the response of a neural oscillator to small perturbations in membrane potential. Its usefulness for predicting the dynamics of weakly coupled deterministic networks has been well characterized. However, the inputs to real neurons may be more accurately described as barrages of synaptic noise. Effective connectivity between cells may thus arise in the form of correlations between the noisy input streams. In this context, we prove mathematically that PRC shape determines susceptibility to synchrony among otherwise uncoupled noise-driven neural oscillators.

We use the Fokker-Planck equation to obtain the probability distribution of the phase of a neural oscillator receiving noisy input. To measure susceptibility to synchrony, the Ito change of variables formula allows us to derive the Lyapunov exponent for a system of two uncoupled oscillators receiving common noise. Since the Lyapunov exponent is a linear functional on the space of periodic functions, we use the Euler-Lagrange formalism to find the optimal PRC that minimizes the Lyapunov exponent. This leads to a 4th order system of nonlinear differential equations, which we can solve to an arbitrary order of accuracy using regular perturbations. The resulting approximation shows that a Type II PRC achieves the minimal Lyapunov exponent, hence producing more robust convergence to synchrony than a Type I PRC. Numerical solution of the 4th order system confirms the analytically derived approximation.