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Presentation Abstract

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Presentation Title: Role of phase response curve skewness on network synchrony of weakly coupled oscillators

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Authors: ***R. DODLA**, C. J. WILSON;
Univ. Texas at San Antonio, SAN ANTONIO, TX

Abstract: Neurons in the basal ganglia fire spontaneously but irregularly, and their collective behavior of synchrony or lack of synchrony may be described by weakly coupled oscillator theory. Phase response curves (PRCs) help in understanding the stability of equilibrium states in such networks. The experimental PRCs, however, are rarely simple, and the corresponding interaction functions computed from the PRCs contain a number of fundamental Fourier modes in contrast to the simple sinusoidal formalism studied in the Kuramoto phase model. To address the full implications of the PRC shape on the network behavior of the coupled neurons, we define a skewness parameter that quantifies how much the PRC is shifted toward longer phases, and study the stability of the possible phase locked states in two phase neurons coupled by either excitatory or inhibitory synaptic connections.

Pairs of mutually excitatory type-1 PRC neurons are found in antiphase (AP) or anti-synchronous state but only when the skewness is small, i.e. only when the PRC is not tilted too much to the longer phases. When the skewness is large, the AP state becomes unstable giving rise to a pair of phase-locked solutions. Such solutions merge to become an inphase (IP) or synchronous state if the synaptic time constant is fast. A pair of mutually inhibitory type-1 PRC neurons are found in the IP state for all skewness values, but AP state becomes bistable with the IP state for moderately to highly skewed PRCs. A pair of mutually excitatory type-2 PRC neurons show synchrony for most skewed PRCs except when they are symmetrical or have very small skew. The Hodgkin-Huxley model PRC can be considered to have moderate skewness and falls in this category. But they also show stable AP state if the PRC is symmetric or the skewness is very small. The AP state can be bistable with the IP state for very small and very large skewness. A pair of mutually inhibitory type-2 PRCs can show, depending on maximum delay in the PRC, bistability between these two states for a large range of intermediate skewness, but stable synchronous state for very small skewness or symmetric PRCs, and other phase-locked states for large skewness.

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Keyword(s): OSCILLATION, weakly coupled oscillators

Phase resonse curve, network synchrony, type-1, type-2 PRC

synchrony, computational, model, theoretical, Parkinson's disease, globus pallidus, subthalamic

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