Predicting Synchronization with Strong Resetting

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Introduction. Several complex behaviors and motor patterns generated by biological systems are the result of well coordinated and strongly interacting populations of neurons [1, 2]. For instance Central Pattern Generators are responsible for the maintenance of vital rhythms (circadian, circulatory, respiratory, etc) [3]. These systems have been successfully studied using interdisciplinary techniques led by biology, physics and dynamical systems. They are usually described by a group of interacting (non-linear) oscillators [4], trapped in limit cycles with huge basins of attraction [5].

Phase Resetting curves. A powerful tool to investigate synchronization are the Phase Resetting curves [6, 7], which assess how the trajectory of such systems deviates when an external perturbation is prompted. With this technique, it is possible to derive informative dynamical properties, such as the Lyapunov exponent, which in turn can be used to understand phase locking and synchrony [6, 2] both in models and experiments [8, 9].

Nevertheless a primary assumption in such formalisms is that the perturbation is brief and weak. If this is not the case, then it is harder to properly estimate Phase Resetting curves and it hinders further development [10, 6]. Not surprisingly, in real systems interactions may be strong and long lasting [11, 12].

Our results. To fill this gap, we propose the use of a simple model for synchronization, with short and strong interactions, in a inhibitory circuit. Mimicking a subcortical brain architecture (striatum), we derive a threshold for synchronization analytically [13]. Based on this simple model, we want to extend results to complex high-dimensional conductance-based models. We show the effectiveness of our approach.

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