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Anticipated synchronization in neuronal motifs

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Anticipated synchronization (AS) is a counterintuitive stable dynamical regime discovered by Voss in the last decade [1]. It consists in the stable synchronized regime between two identical autonomous dynamical systems coupled (unidirectionally) in a master-slave (MS) configuration, if the slave also receives a negative delayed self-feedback. In such regime the slave predicts the master. Although AS has shown to be stable in a variety of theoretical studies [1-3] and in experimental observations [4] with semiconductor lasers and electronic circuits, studies in biological and neuronal systems are still lacking.

The first verification of AS in neuronal models was done between two FitzHugh-Nagumo neurons coupled in a MS configuration with negative delayed self-feedback and driven by white noise [2]. In neuronal networks, AS means that the slave (post-synaptic) neuron can fire spikes right before the master (pre-synaptic) neuron. However the slave delayed self-feedback that induces the anticipated synchronization as suggested by Voss is unrealistic in neuronal circuitry.

Recently, it has been shown that in a biologically plausible neuronal model, the self-feedback can be replaced by an inhibitory loop mediated by an interneuron and chemical synapses [5]. This master-slave-interneuron motif exhibits the usual delay synchronized (DS) regime for small values of the inhibitory synaptic conductance (g) as well as the AS regime for larger g. Moreover, the time delay between consecutive spikes of the master and the slave neurons is a function of the synaptic conductances. Both regimes were shown to be stable for a large set of parameters, different external currents, structural motif and neuron models [6]. Here we investigate the robustness of AS for others motifs, larger populations, neuronal heterogeneity and noise. In all the situations the transition from DS to AS is continuous and smooth.

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