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Modeling the Rhythmic Dynamics of Developing Spinal Cord

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Abstract

Many developing neural systems exhibit spontaneous rhythmic activity: episodes of many neurons firing (say for 10 secs of seconds) separated by long silent phases. In collaboration with expermentalists (M. O'Donovan lab, NIH) we have formulated and studied a set of models that describe the activity patterns in the chick spinal cord, where silent phases can be very long, 10 mins or so. The behavior is network-mediated; a neuron model if isolated does not oscillate episodically. Slow (synaptic) depression accumulates in the functionally excitatory network to terminate an episode and then recovers between episodes. In early development the usually inhibitory GABA/glycine synapses are effectively excitatory and their driving forces (chloride concentrations) vary slowly and contribute to the synaptic depression. We use mean-field models as well as cell-based networks of spiking neurons to understand the dynamics and to design experiments and then analyze results. The structural framework of the models (including bistability on the fast time scale) allows for fast/slow analysis of the emergent rhythmicity.