69. Genetic Clock Oscillator Neural Networks

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Abstract

The control of circadian rhythms in the mammalian brain can be localized to a brain region known as the suprachiasmatic nucleus (SCN). The SCN consists of approximately 20,000 neurons whose firing rates oscillate on an approximately 24 hour rhythm. A large portion of these neurons are capable of maintaining a circadian rhythm in isolation in vitro. The firing rate of each neuron seems to be driven by the cycling of a genetic clock. The precision of the SCN as a whole is a result of the synchronization of these individual clocks, but specific mechanism by which neurons of the SCN synchronize their activity remains unknown. We provide the first biological model for synchronizing these clocks through neurotransmitter mediated communication. The model uses a network of integrate and fire neurons, each with their own independently isolating genetic clock. In this model the firing rate of a neuron is determined by the inputs from other neurons, and the level of mRNA in the genetic clock cycle. In the other direction, the clock cycle is determined by its own dynamics and pushes to the mRNA production rates based on inputs from other neurons. We use this model to show synchronization through this form of communication possible. We further investigate the model by varying the effects of the neurotransmitter on the clock and neuron, and find that only certain neurotransmitter mediated effects lead to synchronization. The results lend support to findings that activity dependent synaptic communication plays a major role in SCN synchronization, and suggest a future path of research focusing on the communication path between a neuron's synapses and it's genetic clock.