Long-Period Rhythmic Synchronous Firing in a Scale-Free Network

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Stimulus information is encoded in the spatial-temporal structures of external inputs to the neural system. The ability to extract the temporal information of inputs is fundamental to brain function. It has been found that the neural system can memorize temporal intervals of visual inputs in the order of seconds [1]. Here we investigate whether the intrinsic dynamics of a large-size neural circuit can achieve this goal. The network models we consider have the scale-free type of topology and abundant diffusive couplings between neurons. We find that hub neurons trigger synchronous firing across the network, loops formed by low-degree neurons determine the rhythm of synchronous firing, and diffusive couplings avoid epileptic firing of the network. Our model successfully reproduces the experimentally observed rhythmic synchronous firing with long periods and supports the notion that the neural system can process temporal information through the dynamics of local circuits in a distributed way.

[1] Sumbre, G., Muto A., Baier H., Poo M-M. (2008) Entrained rhythmic activities of neuronal ensembles as perceptual memory of time interval. Nature 456, 102.