GAP JUNCTIONS PROMOTE SYNCHRONOUS ACTIVITIES IN NETWORK OF INHIBITORY INTERNEURONS

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ABSTRACT

The analysis of neural signals reveals that oscillatory rhythms occur in different brain areas and those in the gamma band (30–80 Hz) seem to be associated to higher cognitive functions. Experimental examples of these phenomena were found in the visual cortex [1], the olfactory system [2], the hippocampus [3] and the auditory system [4]. Moreover, it was suggested that the binding process can be understood by assuming that neurons coding for the different features of the visual scene synchronize their firing activities [5].

Theoretical and experimental findings suggest that networks of inhibitory interneurons contribute to brain rhythms by synchronizing their firing activities and that of principal cells [3,6-17]. However, how assemblies of interneurons synchronize their activity remains poorly understood.

In the neocortex there are different classes of inhibitory GABAergic interneurons. Fast-spiking (FS) cells are a prominent class of GABAergic interneurons that include basket cells providing powerful inhibitory inputs to perisomatic regions of the their target cells. At present the functional role of electrical synapses in networks of inhibitory interneurons it is not well known. However it was shown that electrical synapses containing Cx36 (the major neuronal connexin protein constituents of gap junction channels) are very critical for the generation of widespread, synchronous inhibitory activity [18]. Moreover, electrical synapses could allow networks of inhibitory interneurons to be sensitive to the degree of synchrony of their excitatory inputs (coincidence detectors) [14, 16].

In this work we used a single compartment biophysical model of isolated FS cells to investigate the synchronous regimes occurring in a network of FS interneurons via both chemical and electrical synapses. The time course of inhibitory postsynaptic current between FS cells were determined experimentally and used to model the inhibitory synapses among them. In particular, we studied how the functional features of electrical coupling influenced the synchronisation properties of the network.

It was found that inhibitory synapses alone are able to promote synchrony between FS units and, in agreement with the experimental results, the presence of electrical synapses enhances the coherence properties of the network.

Keywords: synchronization, fast-spiking interneurons, gap junctions.

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