

Poster presentation

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Zero-lag long-range synchronization of Hodgkin-Huxley neurons is enhanced by dynamical relaying

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Background

The synchrony hypothesis postulates that precise temporal synchronization of different pools of neurons conveys information that is not contained in their firing rates. The synchrony hypothesis had been supported by experimental findings demonstrating that millisecond precise synchrony of neuronal oscillations across well separated brain regions plays an essential role in visual perception and other higher cognitive tasks [1]. Albeit, more evidence is being accumulated in favour of its role as a binding mechanism of distributed neural responses, the physical and anatomical substrate for such a dynamic and precise synchrony, especially zero-lag even in the presence of non-negligible delays, remains unclear [2].

Here we propose a simple network motif that naturally accounts for zero-lag synchronization for a wide range of temporal delays [3]. We demonstrate that zero-lag synchronization between two distant neurons or neural populations can be achieved by relaying the dynamics via a third mediating single neuron or population.

Methods

We simulated the dynamics of two Hodgkin-Huxley neurons that interact with each other via an intermediate third neuron. The synaptic coupling was mediated through α -functions. Individual temporal delays of the arrival of pre-synaptic potentials were modelled by a gamma distribution. The strength of the synchronization

and the phase-difference between each individual pairs were derived by cross-correlation of the membrane potentials.

Results

In the regular spiking regime the two outer neurons consistently synchronize with zero phase lag irrespective of

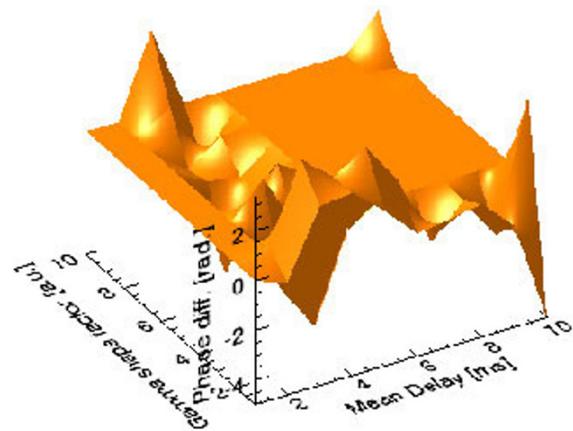


Figure 1

Phase difference between the outer neurons as a function of the mean delay and shape factor of the axonal delays distribution.

the initial conditions. This robust zero-lag synchronization naturally arises as a consequence of the relay and redistribution of the dynamics performed by the central neuron. This result is independent on whether the coupling is excitatory or inhibitory and can be maintained for arbitrarily long time delays (see Fig. 1).

Conclusion

We have presented a simple and extremely robust network motif able to account for the isochronous synchronization of distant neural elements in a natural way. As opposed to other possible mechanisms of neural synchronization, neither inhibitory coupling, gap junctions nor precise tuning of morphological parameters are required to obtain zero-lag synchronized neuronal oscillation.

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