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| Title: | Emergence of synchronization and regularity in firing patterns in time-varying neural hypernetworks |
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| Abstract: | We study synchronization of dynamical systems coupled in time-varying network architectures, composed of two or more network topologies, corresponding to different interaction schemes. As a representative example of this class of time-varying hypernetworks, we consider coupled Hindmarsh-Rose neurons, involving two distinct types of networks, mimicking interactions that occur through the electrical gap junctions and the chemical synapses. Specifically, we consider the connections corresponding to the electrical gap junctions to form a small-world network, while the chemical synaptic interactions form a unidirectional random network. Further, all the connections in the hypernetwork are allowed to change in time, modeling a more realistic neurobiological scenario. We model this time variation by rewiring the links stochastically with a characteristic rewiring frequency f . We find that the coupling strength necessary to achieve complete neuronal synchrony is lower when the links are switched rapidly. Further, the average time required to reach the synchronized state decreases as synaptic coupling strength and/or rewiring frequency increases. To quantify the local stability of complete synchronous state we use the Master Stability Function approach, and for global stability we employ the concept of basin stability. The analytically derived necessary condition for synchrony is in excellent agreement with numerical results. Further we investigate the resilience of the synchronous states with respect to increasing network size, and we find that synchrony can be maintained up to larger network sizes by increasing either synaptic strength or rewiring frequency. Last, we find that time-varying links not only promote complete synchronization, but also have the capacity to change the local dynamics of each single neuron. Specifically, in a window of rewiring frequency and synaptic coupling strength, we observe that the spiking behavior becomes more regular. |
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