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Main theme: Brain Network and Rhythms

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Right
brain

I am the right brain.
I am creativity. A free spirit. I am passion.
Yearning. Sensuality. I am the sound of roaring laughter.
I am taste. The feeling of sand beneath bare feet.
I am movement. Vivid colors.
I am the urge to paint on an empty canvas.
I am boundless imagination. Art. Poetry. I sense. I feel.
I am everything I wanted to be.

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Effect of Small-World Connectivity on Fast Sparsely Synchronized Cortical Rhythms

Sang-Yoon Kim and Woochang Lim*

Computational Neuroscience Lab., Department of Science Education, Daegu National University of Education, Daegu 705-115, Korea

*Correspondence e-mail address: woochanglim@dnue.ac.kr

Fast cortical rhythms with stochastic and intermittent neural discharges have been observed in electric recordings of brain activity. For these fast sparsely synchronized oscillations, individual neurons fire spikings irregularly and sparsely as Geiger counters, in contrast to fully synchronized oscillations where individual neurons exhibit regular firings like clocks. We study the effect of network architecture on these fast sparsely synchronized rhythms in an inhibitory population of suprathreshold fast spiking (FS) Izhikevich interneurons (which fire spontaneously without noise). We first employ the conventional Erdös-Renyi random graph of suprathreshold FS Izhikevich interneurons for modeling the complex connectivity in neural systems, and study emergence of the population synchronized states by varying both the synaptic inhibition strength J and the noise intensity D. Fast sparsely synchronized states of relatively high degree are found to appear for large values of J and D. However, in a real cortical circuit, synaptic connections are known to have complex topology which is neither regular nor random. Hence, for fixed values of J and D we consider the Watts-Strogatz small-world network of suprathreshold FS Izhikevich interneurons which interpolates between regular lattice and random graph via rewiring, and investigate the effect of small-world synaptic connectivity on emergence of fast sparsely synchronized rhythms by varying the rewiring probability p from short-range to long-range connection. When passing a small critical value p^*_c, fast sparsely synchronized population rhythms are found to emerge in small-world networks with predominantly local connections and rare long-range connections. This transition to fast sparse synchronization is well characterized in terms of a realistic "thermodynamic" order parameter. For further understanding of this transition, we also investigate the effect of long-range connections on dynamical correlations between neuronal pairs, and find that for $p > p^*_c$, global synchronization appears in the whole population because the spatial correlation length covers the whole system thanks to sufficient number of long-rang connections. The degree of fast sparse synchronization for $p > p^*_c$ is also measured in terms of a realistic "statistical-mechanical" spiking measure. As p is increased from p^*_c, the degree of population synchrony becomes higher, while the axon "wire length" of the network also increases. At a dynamical-efficiency optimal value p^*_{ε}, there is a trade-off between the population synchronization and the wiring economy, and hence an optimal fast sparsely-synchronized rhythm is found to occur at a minimal wiring cost in an economic small-world network.

Key words: Suprathreshold FS Izhikevich interneurons, Small-world network, Fast sparsely synchronized cortical rhythm