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Computational Study of the Role of Spatial Organization in the Synchronicity of Firing Events in Spiking Neuronal Networks

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In the brain, neurons are arranged in networks at the microscopic scale whose connectivity and spatial arragements are far from random. An important theoretical and biological question is whether these kinds of organization are side effects of how the brain develops or an important component of brain functionality. As a way to tackle this question, here we asses computationally whether spatial organization of clusters of neurons in networks of spiking neurons offer advantages to the overall network firing synchronization. For this, we vary neuronal cluster connectivity for two different spatial distributions of clusters: one where clusters are arranged in biologically-inspired columns and the other where neurons from different clusters are spatially intermixed. We characterize each case by measuring the degree of neuronal spiking synchrony as a function of the number of connections per neuron and the degree of intercluster connectivity. We find that in both cases as the number of connections per neuron increases, there is an asynchronous to synchronous transition dependent only on intrinsic parameters of the biophysical model. More importantly, we find that for a specific number of connections per neuron and intercluster connectivity, the two spatial distributions of clusters differ in their response where the clusters arranged in columns have a higher degree of synchrony than the clusters that are intermixed. Implications to anatomy and brain function will be discussed.