High frequency neurons contribute to define effective connectivity in brain networks

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The emergence of flexible information channels in brain networks is a fundamental question in neuroscience. Understanding the mechanisms of dynamic routing of information would have far-reaching implications in a number of disciplines ranging from biology and medicine to information technologies and engineering.

In this presentation, we study how signals transmit in simple bidirectionally-coupled networks. In these networks, each node represents a unit composed of excitatory and inhibitory neurons and all nodes, except one, produce a local oscillation with frequency ν_0 in the gamma range. An inhomogeneity is introduced by placing the remaining node –called source node– to oscillate at a different intrinsic frequency $\nu = \nu_0 + \triangle\nu$. We find that the presence of this particular node leads to reliable transmission of signals and establishes a preferential direction of information flow.

Our results show that slowly varying local signals can better propagate along the network if the receiving node has a higher intrinsic firing rate. Moreover, we find that high frequency units determine the direction of signal propagation, so the effective connectivity in such a network. While structural network connections are bidirectional and symmetric, in the effective network the connections are directed outward from the high frequency node, being highly influential in the activity propagation despite the symmetric homogeneous structure. Thus, by raising the firing rate a low degree node can behave as a functional hub, spreading its activity patterns polysynaptically in the network. Therefore, the firing rate, which might be easily controllable, becomes a tunable parameter that introduces directionality and enhances the reliability of signal transmission. We find that our results are generic and the same mechanism is observed in networks with more complex topologies.

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