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Recent studies have been using graph theoretical approaches to model complex networks, and how their hardwired circuitry relates to their dynamic evolution in time. Understanding how configuration reflects on the coupled behavior in a system of dynamic nodes can be of great importance to networks in the life sciences. For example, it can inform on how the brain connectome is affecting brain function. However, the effect of connectivity patterns on network dynamics is far from being fully understood.

We investigate the connections between edge configuration and dynamics in a simple oriented network with Wilson-Cowan type nodes, composed of two interconnected cliques (representing two interconnected excitatory/inhibitory neural populations typical of brain feedback circuitry) [1, 2]. We observe the robustness of the coupled dynamics to certain changes in the network architecture and its vulnerability to others. We explore the idea of having structure as a bifurcation parameter – structure encoded in the graph adjacency and Laplacian matrices. Using configuration dependent phase spaces and a probabilistic extension of bifurcation diagrams in the parameter space, we investigate the relationship between classes of system architectures and classes of their possible dynamics. We differentiate between the effects on dynamics of varying edge weights, density, and configuration. For example, we show that increasing the number of connections between the two cliques is not equivalent to strengthening the existing connections, but that there are certain dynamic aspects that are robust to the network configuration when the edge density is fixed [1]. A more in depth study of the network graph (using the distribution of the adjacency and graph Laplacian spectra over sampled configurations) clarifies that the robustness in dynamics is not a parameter-dependent property, or a numerical artifact, but rather emerges from intrinsic features of the underlying graph [2].

We discuss how our results can be used to understand the link between brain connectivity patterns and dynamics in the prefrontal-limbic brain network that regulates emotion. In particular, we present an application in which our measures, in conjunction with neuroimaging data form humans, were able to explain differences in prefrontal-limbic regulation efficiency between schizophrenia patients and healthy controls [3].

References

[1] Rădulescu A, Verduzco-Flores S. Nonlinear network dynamics under perturbations of the underlying graph, *Chaos* 25 (1), 2015.

[2] Rădulescu A. Neural network spectral robustness under perturbations of the underlying graph, *Neural Computation* 28, 2016.

[3] Rădulescu A, Mujica-Parodi L.R. Network connectivity modulates power spectrum scale invariance, *NeuroImage* 90, 2014.