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Dynamics of hierarchical neural networks

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Neural networks are organized hierarchically across many scales of dimension, from cellular neuronal circuits via mesoscopic networks at the level of columns, layers and areas to large-scale brain systems. However, the structural organization and dynamic capabilities of hierarchical networks are, so far, poorly characterized. We investigated the contribution of different features of network topology to the dynamic behavior of hierarchically organized neural networks. Prototypical representatives of different types of hierarchical networks as well as two biological neural networks were explored with a three-state model of node activation for systematically varying levels of random background network stimulation. The results demonstrated that two principal topological aspects of hierarchical networks, node centrality and network modularity, correlate with the network activity patterns at different levels of spontaneous network activation. Moreover, we observed that in hierarchical networks, noise (the rate of spontaneous excitations) is the driving force behind some forms of organized dynamics. The approach also showed that the dynamic behavior of the cerebral cortical systems network in the cat is dominated by the network's modular organization, while the activation behavior of the cellular neuronal network of *Caenorhabditis elegans* is strongly influenced by hub nodes. Generally, our results demonstrate the interaction of multiple topological features and dynamic states in the function of complex neural networks.