Graph coloring predicts the dynamics of neuronal networks

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Neuronal networks exhibit a rich dynamical repertoire, a consequence of both the intrinsic properties of neurons and the structure of the network. While a number of studies have effectively characterized the global structure of networks, much less is known about how the structure constrains the behavior of dynamical systems embedded at the nodes of the network. In a variety of neuronal systems it has been hypothesized that inhibitory interneurons corral principal neurons into transiently synchronous ensembles that encode sensory information and sub–serve behavior. How does the structure of the network facilitate such spatiotemporal patterning? We establish a relationship between a structural property of the network, its colorings [A coloring of a network is the assignment of colors to the nodes of the network such that nodes that are directly connected to each other are assigned different colors], and the dynamics it constrains. Using a model of the insect antennal lobe we show that our description allows the identification of transiently synchronous groups of inhibitory interneurons that switch between active and quiescent states in a manner determined by intrinsic neuronal properties and specific features of the network structure. We then used the coloring of the inhibitory sub–network to construct a space in which the collective activity of the excitatory principal neurons reliably formed a series of orthogonally propagating waves. In effect, by reordering the neurons according to a prescription dictated by the network structure, we were able to extract low dimensional dynamics (synchrony, clustering and traveling waves) from a randomly connected network.