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A model of metastable dynamics during ongoing and evoked cortical activity[1]

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The dynamics of simultaneously recorded spike trains in alert animals often evolve through temporal sequences of metastable states. Little is known about the network mechanisms responsible for the genesis of such sequences, or their potential role in neural coding. In the gustatory cortex of alert rates, state sequences can be observed also in the absence of overt sensory stimulation, and thus form the basis of the so-called 'ongoing activity'. This activity is characterized by a partial degree of coordination among neurons, sharp transitions among states, and multi-stability of single neurons' firing rates. A recurrent spiking network model with clustered topology can account for both the spontaneous generation of state sequences and the (network-generated) multi-stability. In the model, each network state results from the activation of specific neural clusters with potentiated intra-cluster connections. A mean field solution of the model shows a large number of stable states, each characterized by a subset of simultaneously active clusters. The firing rate in each cluster during ongoing activity depends on the number of active clusters, so that the same neuron can have different firing rates depending on the state of the network. Because of dense intra-cluster connectivity and recurrent inhibition, in finite networks the stable states lose stability due to finite size effects. Simulations of the dynamics show that the model ensemble activity continuously hops among the different states, reproducing the ongoing dynamics observed in the data. Moreover, when probed with external stimuli, the model correctly predicts the quenching of single neuron multi-stability into bi-stability, the reduction of dimensionality of the population activity, the reduction of trial-to-trial variability, and a potential role for metastable states in the anticipation of expected events. Altogether, these results provide a unified mechanistic model of ongoing and evoked cortical dynamics.

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