

## Structural Mechanisms for Persistent Activity and Autonomous Transitions in Spatial Networks

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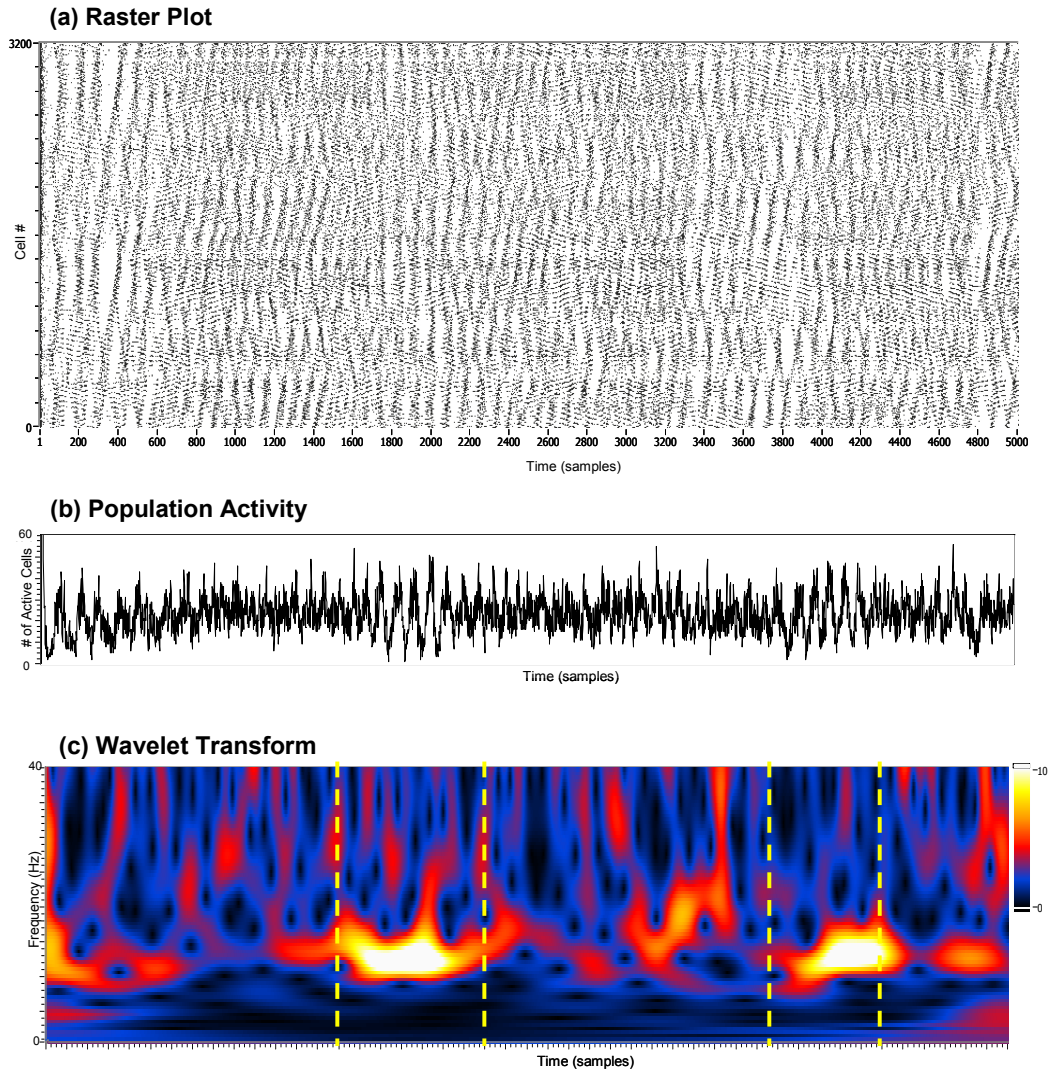
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Transitions in neural population activity (e.g., as measured by EEG) are often assumed to be the result of (i) external stimuli or (ii) ongoing random perturbation. Using spatial neural network models, we demonstrate that complex persistent activity with ongoing transitions can be maintained without either of these factors. The models consist of two-layer networks with inhibitory and excitatory populations of up to 20,000 spiking units with columnar connectivity. Units are connected to their neighbours in the same population, as well as to the corresponding cells in the opposite population. The simulations were initiated with a single, random, spatially-distributed stimulus. In the case of fully connected networks, the activity initiated by such a stimulus quickly dissipated. We then proceeded to create heterogeneous networks by randomly deleting cells. When deletions reached a threshold, network activity remained persistent. We also found that at the lowest and highest levels of deletion the probability of persistent activity was critically dependent on the spatial asymmetry between populations thus indicating that *local* inhibitory-excitatory balance plays an important role at these levels of heterogeneity. However, such local imbalance was not absolutely necessary. The probability of persistent activity can be increased even with fully symmetrical deletions that maintain the local balance of synaptic excitation and inhibition (although less reliably and at a much narrower range of deletion rates). This finding illustrates that geometrical changes *per se*, and not just changes to inhibitory-excitatory balance, can be a core mechanism for the genesis of persistently active networks. Most notably perhaps is the fact that the persistent activity showed prominent autonomous transitions. The activity transitioned between well-defined low frequency oscillations of varying frequency and more random-like activity with higher frequency components. These transitions persisted in the absence of any external stimulation. The findings demonstrate that ongoing changes seen in population activity may be the result of structural network heterogeneity and that these transitions do not require external stimuli or stochastic perturbations. The observations could also help explain the importance of cell loss for tuning neural dynamics during development as well as the effects seen following excessive cell death in post-traumatic epilepsy and in neurodegeneration.

## Autonomous Transitions in Spatial Networks



*Ohayon et al Figure 1:* (a) The raster plot of activity for all remaining cells in a 40 x 40, two-layer, heterogeneous network following diffuse cell deletion at probability  $p = 0.4$ . (b) The population activity for the same simulation. Note that distinct low-frequency, high-amplitude, waves appear at beginning of the run and then return at approximately iterations # 1600-2200 and iterations # 3800-4300. (c) The autonomous transitions in and out of low frequency are reflected in the wavelet transform of the population activity. No structural changes, stimuli or noise were applied during the simulation -- the transitions in population activity are thus autonomous of any external factors. These autonomous frequency transitions correspond to ongoing changes in the spatial nature of the propagating wave-fronts.