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Presentation Abstract

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Presentation Title: The role of interplay between network density and synaptic connectivity in tuning neural dynamics and cognition

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Abstract: Previously we have demonstrated that network density can be a critical factor in determining the persistence and complexity of neural population activity. The question then arises as to the co-effects of density and synaptic coupling. In this study we use computational models to demonstrate how these co-factors impact activity in large-scale networks. Models consisted of multi-layered networks of up to 100,000 spiking units. The simulations included both inhibitory and excitatory units connected in columnar geometries. Synaptic coupling strengths were swept between and within the excitatory and inhibitory populations. Connectivity was established by starting with a homogeneous network with all units and local connections present (100% density). Network density was reduced by randomly removing units and their respective connections at 10% increments (down to 10% density). Multiple simulations (1000) were run at each density, with random initial conditions across all units, to examine variability in response and sensitivity to initial conditions. The resultant population activity was characterized using a calibrated amplitude wavelet transform. Simulations showed that although both synaptic and density measures could individually change the persistence of activity and its complexity, the simultaneous modulation of both factors could have significant co-effects on the population activity. For example, certain densities were required to maintain complex persistent activity for given connectivity weights. Conversely, activity would cease to reliably propagate if coupling was outside of bounds for a given density. We show that these effects were not always monotonic with the resultant networks often exhibiting multi-stability (i.e., highly sensitive to initial conditions) and varying in their spectral and transition properties. These profound changes in the initiation and propagation of activity illustrate possible co-mechanisms for modulating cognitive features such as memory trace persistence, attention and decision making. We also show how the anatomical features underlying such cognitive effects might be identified in human brain networks by examining density and coupling measures in postmortem tissue at the network and synaptic levels.

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