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Poster presentation

Inferring large-scale brain connectivity from spectral properties of the EEG

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Introduction

Study of recorded electroencephalogram (EEG) data has demonstrated that the brain exhibits global dynamics with specific spectral properties [1]. In particular, it is noted that large-scale brain activity consists of the superposition of background "pink noise" and a number of specific frequency bands whose spacing reduces the potential for cross-talk (band peaks are evenly spaced on a logarithmic scale). The relationship between network topology and observed activity is a topic of ongoing research, but it has been observed anatomically that large-scale connectivity in the brain is nonrandom, displaying a small-world topology [2]. This topology maximizes the complexity of the brain dynamics, allowing for a large repertoire of physiologically relevant activity patterns. Thus, it is desirable to infer details regarding the connectivity of a neural network based on observation of its dynamics.

Methods

Using a stochastic dynamical model of large-scale brain activity [2,3], we found a relationship between the power spectrum of EEG traces and the eigenvalues of the connectivity matrix. Because many different matrices have the same set of eigenvalues, the EEG spectrum alone is not sufficient to determine the underlying network connectivity. We thus impose one constraint: the connectivity matrix must have a small-world network topology. We then solve the inverse-eigenvalue problem [4], obtaining a family of connectivity matrices compatible with this condition, that in the simulations generate EEG with the power spectrum experimentally observed.

Results

The reconstructed connectivity matrices display globally balanced excitation and inhibition (positive and negative entries, respectively) as well as the presence of hubs, which are characteristic of small-world networks (Figure 1).

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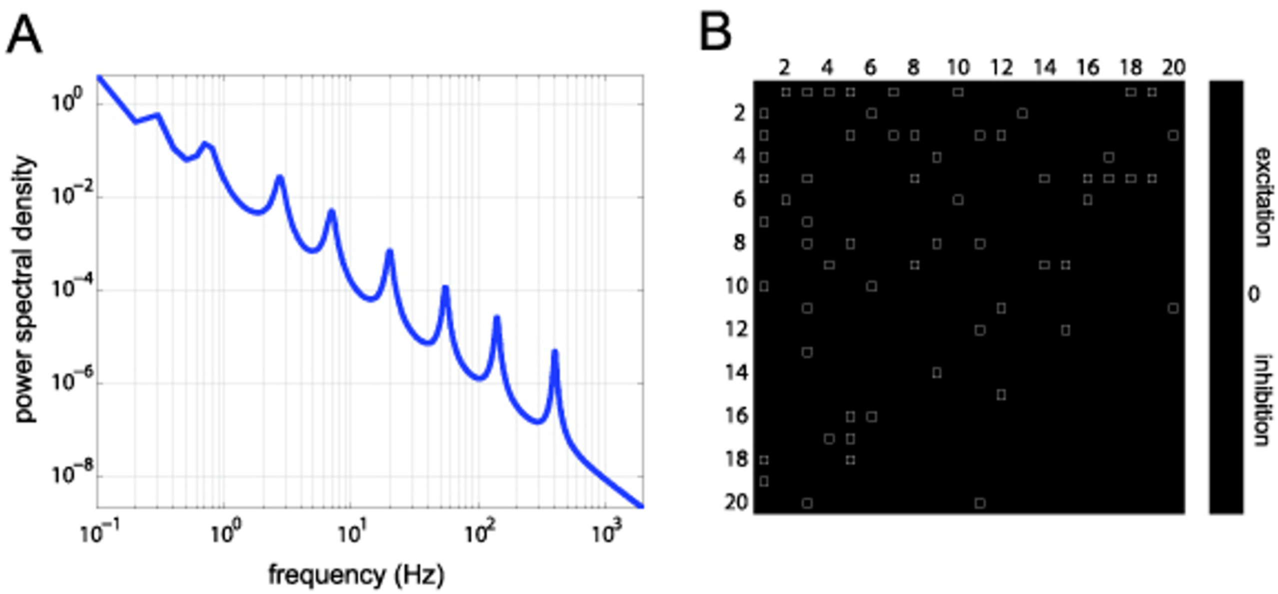

Figure 1
Connectivity matrix reconstructed from the EEG power spectrum. A: Simulated power spectrum of EEG traces. B: Connectivity matrix that leads to an EEG with the same power spectrum as in A. Black squares represent the underlying small-world network topology.