Functional Brain Network Mechanism of Hypersensitivity in Chronic Pain

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Fibromyalgia (FM) is a chronic widespread pain condition characterized by augmented multi-modal sensory sensitivity. Although the mechanisms underlying this sensitivity are thought to involve an imbalance in excitatory and inhibitory activity throughout the brain, the underlying neural network properties associated with hypersensitivity to pain stimuli are largely unknown. In network science, explosive synchronization (ES) was introduced as a mechanism of hypersensitivity in diverse biological and physical systems that display explosive and global propagations with small perturbations. We hypothesized that ES may also be a mechanism of the hypersensitivity in FM brains. To test this hypothesis, we analyzed resting state electroencephalogram (EEG) of 10 FM patients. First, we examined theoretically well-known ES conditions within functional brain networks reconstructed from EEG, then tested whether a brain network model with ES conditions identified in the EEG data is sensitive to an external perturbation. We demonstrate for the first time that the FM brain displays characteristics of ES conditions, and that these factors significantly correlate with chronic pain intensity. The simulation data support the conclusion that networks with ES conditions are more sensitive to perturbation compared to non-ES network. The model and empirical data analysis provide convergent evidence that ES may be a network mechanism of FM hypersensitivity.