

Dynamic brain network states during fMRI neurofeedback in chronic tinnitus: Insights from a multi-seed co-activation pattern (CAP) analysis

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Chronic tinnitus manifests as a phantom auditory percept, often accompanied with distress. Currently, neural dynamics underlying treatment response remain unclear. Using a longitudinal data set from a fMRI neurofeedback (NF) trial targeting bilateral auditory downregulation in 21 patients with tinnitus (NCT05737888), we investigated transient co-activation patterns (CAPs) as potential markers of neural modulation and clinical change across the NF training. Group CAPs (gCAPs) were generated from five seeds (right planum temporale, bilateral parietal operculum 3, and bilateral auditory cortices) across NF and transfer runs. We also implemented a scalable python-based CAP pipeline with temporal thresholding, k -means clustering, and gCAPs generation able to process large input data. Across ROIs, gCAPs reproduced combinations of canonical attention, salience, and sensorimotor Yeo7 networks, showing longer, more stable states, and reduced transitions during NF, particularly in auditory and opercular regions. Preliminary clinical correlations indicate that baseline gCAP metrics from PTr and OP3r were associated with tinnitus handicap (THI), anxiety (STAI-Y1), and depression (BDI). In contrast, several auditory-seed gCAP metrics at early post-assessment correlated with STAI-Y2 and sleep quality (PSQI) after the intervention. Average gCAP duration and resilience best tracked symptom changes across different k , while entries were consistently baseline-predictive for BDI, THI, and WHODAS, across multiple ROIs. These results demonstrate the feasibility of multi-ROI CAP analysis in task-based NF and support the relevance of dynamic network measures for characterizing therapeutic engagement. Further analyses will test predictive relationships between baseline CAP profiles and long-term clinical improvement, advancing the identification of network-level biomarkers in NF for tinnitus.