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Official Title of study: Investigating Electroencephalographic Predictors of Default Mode Network Anticorrelation for Personalized Neurofeedback

NCT number: NCT05592600

Study Protocol

Participants attended two sessions at the Temple University Brain Research & Imaging Center with time between the two scanning sessions ranging from 3 to 62 days (mean = 12.61 days, median = 7 days). The study protocol was approved by the Drexel University Institutional Review Board. Prior to the main experiment, written informed consent was obtained from each participant alongside demographic information. Participants then filled out a series of questionnaires pertaining to different mental health conditions, including a crosscutting assessment: DSM-5 Self-Rated Level 1 Cross-Cutting Symptom Measure-Adult (DSM XC), a measure of impairment: WHO Disability Assessment Schedule-12 (WHODAS-12), a measure of anxiety: General Anxiety Disorder-7 (GAD-7), measures of depression: Patient Health Questionnaire-9 (PHQ-9), Ruminative Response Scale (RRS), and a measure of trait mind-wandering: Mind-Wandering Deliberate-Spontaneous scale (MWD-S). Participants were trained on all experimental tasks and informed of the full EEG-fMRI study procedure. Additionally, head circumference was measured from glabella to inion to determine EEG cap size to ensure that we had the proper fit for them. On scanning days, measures of state anxiety using the state scales of the State Trait Anxiety Inventory (STAI-S) were obtained, and participants provided an estimation of number of hours slept the night before. Scanning sessions ran for a total of 2-hours each, with approximately 1-hour dedicated to set up of the EEG system and MRI safety procedures. Prior to cap setup, subjects were checked for metal using first a metal detector wand and then using a Ferroguard standing detector. Once confirmed that all metal items had been removed, participants were seated. Alcohol wipes were used to clean the forehead of oil and debris, and then the appropriate cap was placed on the head with Fp1 and Fp2 electrodes aligned directly above the line of the eyebrows and secured with washer stickers. The cap was tugged and smoothed to remove all bubbling, and a secure Velcro strap was attached under the chin of each participant. All electrodes were then filled with electrolyte gel.

The scanning protocol included collection of localizers and a T1 weighted Magnetization Prepared Rapid Gradient Echo (MPRAGE) structural scan. Functional MRI scans were collected across two tasks, Gradual-Onset Continuous Performance Task (GradCPT) and resting-state multidimensional experience sampling (rs-MDES). The second scanning session was identical to the first scanning session, excluding the structural scan, which was Fast Low Angle Shot (FLASH) instead of MPRAGE sequence. The GradCPT was run for 8 minutes during which participants were instructed to respond with a button press to frequent city scenes and withhold response to the presentation of rare mountain scenes. Three runs of the rs-MDES task were collected at each session wherein participants visually fixated on a cross at the center of their screen and let their minds wander. Intermittent thought probes appeared pseudorandomly every 45-60 seconds which were rated by participants at their own pace. Thirteen probes were presented in sequence, capturing unique dimensions of subjective experience for 6 trials across the duration of each run (3 rs-MDES runs per session).

Statistical Analysis Plan

For the primary outcome, EEG and fMRI data from all task conditions, runs, and sessions were analyzed. Preprocessed blood-oxygen-level-dependent (BOLD) signals were extracted from the default mode network (DMN) in the fMRI data. Band-limited power amplitude at multiple frequency bands was extracted from preprocessed EEG data. A mass-univariate Spearman rank correlation (ρ) analysis between these EEG features and BOLD activity within the DMN was performed within each run. Correlations were then averaged across runs within subjects. Statistical significance was assessed within via a one-sample *t*-test against zero on the averaged ρ values, with *P* values corrected for multiple comparisons using the false discovery rate.