

Relating Psychological and Clinical Scales to Network Separation during Mindfulness-Based Neurofeedback in Borderline Personality Disorder

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Introduction

People with borderline personality disorder (BPD) exhibit hyperactivity in their default mode network (DMN),¹ a set of brain regions including the medial prefrontal cortex (mPFC) and posterior cingulate cortex (PCC) which are typically activated when not doing a specific task, and whose overactivity is linked to decreased mindfulness and increased rumination.² In contrast, the frontoparietal control network (FPCN), with a key node in the dorsolateral prefrontal cortex (DLPFC), is activated when focusing on a specific task requiring executive functions such as working memory and attention,³ and is anticorrelated with the DMN.⁴ Our clinical trial aims to test whether mindfulness-based neurofeedback (mbNF) on the FPCN and DMN can enhance the effect of gold standard dialectical behavioral therapy (DBT) on BPD.⁵ The present analysis focuses on whether baseline clinical and psychological measures predict change in FPCN-DMN separation following mbNF, and whether change in state mindfulness parallels change in network separation. Analyses relating network connectivity to baseline scales are planned for the conclusion of the initial R61 phase of this trial, which is expected to occur prior to the rtFIN conference.

Methods

This study is a longitudinal randomized controlled trial. Participants receive comprehensive initial assessments and baseline measures such as the Sense of Agency Scale (SoAS), Mindful Awareness and Attention Scale (MAAS), Borderline Symptom List (BSL), and Beck Depression Inventory (BDI). Diagnostic eligibility is determined by the Diagnostic Interview for Personality Disorders (DIPD) BPD questions. This clinical trial is in the initial R61 phase, and will transition to the second R33 phase pending alignment with go/no-go criteria (not discussed in this abstract).

Participants deemed eligible for the study receive fMRI mindfulness-based neurofeedback (mbNF). Personalized brain networks are extracted using independent component analysis on participant resting state data. After receiving training on a mindful describing exercise, participants employ this practice to modulate FPCN-DMN difference. Real-time visual feedback shows participants their relative network activity. Immediately before and after the feedback runs, participants complete a transfer task in which they complete the mindful describing practice but do not receive any feedback. Crucially, participants are randomized to the experimental or yoked sham condition; experimental participants receive feedback based on their network activity, while yoked sham participants receive feedback from another participant. Participants complete the State Mindfulness Scale (SMS) twice on mbNF scan day, once before and once after mbNF. Following mbNF, participants receive 20 weeks of remote DBT skills group, completing many follow-up clinical assessments and two follow-up fMRI scans to assess changes in clinical characteristics and network connectivity, respectively.

The present analysis assesses whether baseline scales (SoAS, MAAS, BSL, BDI, SMS) predict (1) control over mbNF as measured by average FPCN-DMN separation, and (2) change in FPCN-DMN separation. We also investigate whether change in SMS from pre- to post-mbNF parallels change in FPCN-DMN separation. These analyses are conducted in the experimental group (participants receiving real neurofeedback).

Additional planned analyses focus on whether within-DMN and/or FPCN-DMN *connectivity* change to mbNF correlates to (1) baseline scales and (2) change in state mindfulness. Within-DMN connectivity will be calculated by correlating mPFC and PCC timeseries, while mPFC-DLPFC connectivity will serve as the measure of FPCN-DMN anticorrelation. Connectivity peaks with mPFC, identified in a composite seed-based connectivity map across all subjects, will be used to functionally define the PCC and DLPFC.

Results

High baseline trait mindfulness (MAAS) correlates with average network control across no-feedback transfer runs in participants receiving real neurofeedback, supporting FPCN-DMN separation as a potential biomarker of trait mindfulness ($n=14$, $p<0.05$, uncorrected). MAAS is also correlated with average control across feedback runs, but this is not statistically significant ($r=0.38$, $p>0.05$, uncorrected). No baseline scales predict change in control, either from the pre-mbNF to post-mbNF transfer tasks or from the first to final mbNF feedback runs. These exploratory results do not survive multiple corrections in this preliminary sample.

Conclusions

Our results indicate that increased baseline trait mindfulness may predict greater FPCN-DMN separation in this preliminary sample. This effect is significant across the no-feedback transfer runs but not the feedback runs, suggesting that FPCN-DMN separation may be a better biomarker of trait mindfulness in the absence of feedback. Preliminary results also indicate that baseline sense of agency, trait mindfulness, state mindfulness, and BPD symptom severity do not predict change in FPCN-DMN separation.

However, this is a highly exploratory finding in a limited sample size. We expect to complete the R61 phase prior to the conference and look forward to validating these findings in the full R61 sample and comparing between experimental and yoked sham participants.

At the conclusion of the R61 phase, we also eagerly anticipate assessing whether baseline sense of agency, trait mindfulness, state mindfulness, BPD symptom severity, and depression affect within-DMN and FPCN-DMN connectivity change in response to mbNF, if change in state mindfulness parallels connectivity change, and whether these relationships differ between the experimental and yoked sham groups.

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