Parietal Influences on Executive Functions and Psychopathology: Connecting the Dots Between Self-Regulation and Psychopathology

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Abstract
This study demonstrates the effects of LORETA Neurofeedback (LNFB) in the precuneus for self-regulation to address a heterogeneous set of psychological disorders and comorbidity. LNFB influenced significant improvements in executive functions and concomitant decreases in endorsement of psychopathology.

Introduction
Self-regulation is a highly adaptive and powerful process (Baumeister, 2005). In the most basic sense executive functions are dependent on the ability to self regulate with respect to the functional integrity and neural efficiency of the brain and its networks (Cannon, et al 2007; 2009; 2011; 2012; Cannon, 2012). The precuneus is one of the last cortical regions to myelinate and therefore should be an important loci for the adaptive functioning of the individual.

LORETA neurofeedback is an operant conditioning technique that provides the user information about the EEG current source density in a specific intracortical region of interest.

The user can then change the EEG CSD at the ROT to improve cognitive, attentional and affective processes (Cannon, et al., 2007, 2008, 2009, 2011, 2012). This study hypothesized that LNFB in a parietal ROT would positively influence executive functions and reduce endorsement of psychopathology. This study was designed to improve self regulation. It was not specific to any disorder.

Methods
13 volunteers – with mean age 28 (SD 9.1). The participants included 5 non-clinical university students, and 8 adults with heterogeneous, comorbid psychiatric diagnoses (SUD in remission, ADHD, MDD, and Anxiety).

Exclusion criteria included prior history of head injury or TBI; epilepsy or other neurological syndrome; psychiatric disorder with psychosis or recent use of alcohol or drugs within 2 weeks of the procedure.
Participants completed five training sessions per week with six, five-minute training rounds within each session. Each session took 1 hour to complete.

The participants received positive reinforcement for increasing alpha CSD (8-13Hz) in a 3 voxel cluster of neurons in left precuneus (shown below).

- We utilized neurophysiological measures, Personality Assessment Inventory (PAI) and Delis-Kaplan Executive Function System (DKEFS) verbal fluency and color-word interference tasks for pre and post training measures. PAI showed reliability of .84 at 2 – 4 week test-retest.

Figure 1 above: Shows the results for the paired contrasts for total power and alpha power at the ROT. Post total power EOB > Pre EOB total power t(12) = 3.60, p = .004; post eob alpha > pre eob alpha t(12) = 2.93, p = .013; post total power > pre total power t(12) = 2.90, p = .013; post eob alpha > pre eob alpha t(12) = 3.36, p = .006. Figure 2 (below) shows the pre and post contrasts for the PAI scales. Figure 3 (right-top) shows the results for the paired contrasts for pre and post color-word interference task scores. Figure 4 (left) shows the results for pre and post verbal fluency scores.

Discussion and Conclusions
- LNFB in the precuneus influenced significant improvements in the switching subtest of the DKEFS. The letter and category subtests increased in the desired direction as well. The trained frequency in the specific ROT did show significant increases pre and post training. Network analyses are forthcoming.

- The PAI scales show significant reduction post training 6 of the clinical scales. All scales however, decrease in the desired direction.

- The significant improvements in executive functions and reduction in psychopathological distress occurred in controls in 12 days on average and 15 days on average for the clinical group.

- We are not aware of any study to date showing these specific improvements in executive functions and concordant reductions in psychopathological scores.

Limitations
- Larger sample sizes are desired. Specific groups of disorders are desired.
- A larger set of psychometrics would also be beneficial.
- A control group might be necessary; however, we have recently published data showing that the reliability for this ROT at 30 days is .94 in ECB and .83 in EOB. Therefore we would not expect the degree of change found in this study to occur randomly (Cannon, et al., 2012)

- The localization of this ROT might also be questioned; however, we have published data demonstrating LORETA to localize activity in this ROI and other ROIS in the default network with fMRI (Cannon, et al., 2011)