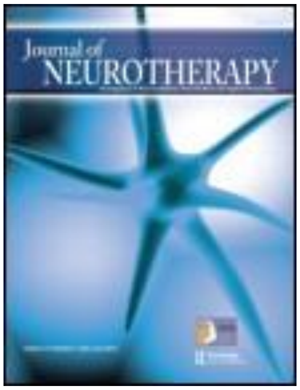

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Rex L. Cannon [a b]

[a] Clinical Neuroscience, Self-Regulation and Biological Psychology Laboratory, Department of Psychology , University of Tennessee , Knoxville , Tennessee , USA

[b] Cole Neuroscience Center: Memory Disorders Clinic, University of Tennessee Graduate School of Medicine , Knoxville , Tennessee , USA

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LORETA NEUROFEEDBACK: ODD REPORTS, OBSERVATIONS, AND FINDINGS ASSOCIATED WITH SPATIAL SPECIFIC NEUROFEEDBACK TRAINING

Rex L. Cannon[1,2]

[1]Clinical Neuroscience, Self-Regulation and Biological Psychology Laboratory, Department of Psychology, University of Tennessee, Knoxville, Tennessee, USA
[2]Cole Neuroscience Center: Memory Disorders Clinic, University of Tennessee Graduate School of Medicine, Knoxville, Tennessee, USA

Neurotherapeutic techniques continue to advance in sophistication and complexity, and as such so does the need to reference odd occurrences or adverse reactions as a result of training in different regions of the brain. This is important to the field of neurotherapy in addition to those practitioners who may encounter patients on medications at the time of training, and this type of information can only add to the armamentarium of tools at our disposal. We discuss noted odd occurrences that have transpired during our studies employing LORETA neurofeedback (LNFB) in both children and adults. We also discuss negative events reported by patients or parents and medications interactions with LNFB. Positive results are also discussed. The field of neurofeedback can benefit immensely from more reports of this type.

As neurotherapeutic techniques advance in sophistication, a need arises to report odd effects or adverse reactions to specific protocols or procedures. LORETA neurofeedback (LNFB) is a recent advancement that permits localized operant conditioning of the EEG in specific regions of the cortex and specific EEG current source density ranges (Cannon, Congedo, Lubar, & Hutchens, 2009; Cannon et al., 2007; Congedo, Lubar, & Joffe, 2004). Our laboratory has conducted numerous studies with clinical and normal populations using LNFB and has kept detailed records of both cognitive and affective improvements as well as odd or unexpected events associated with these training protocols.

Our first study involved eight normal college students who completed 30 sessions of LNFB in the cognitive division of the anterior cingulate gyrus (AC). These participants learned to increase 14–18 Hz activity in the region of training (Cannon et al., 2007). Prior to this study, we conducted a pilot study to determine the most robust frequency to train in the AC. We trained three individuals to increase low-beta power and three to increase theta power, given its prominence in the AC. At Session 8, on average, the participants increasing theta began to have excessive tear production during the LNFB training rounds. These episodes were quite profound and disrupted the recordings. This response occurred between Sessions 8 and 10, at which time we decided to switch the individuals to the low-beta frequency, which did not produce this effect. None of these participants reported any emotional symptoms to accompany the excess tear production (e.g., sadness or anxiety), and after switching protocols, all continued on with the low-beta protocol without further incident. The studies that followed produced positive changes in Weschler Adult Intelligence Scale (3rd ed.; WAIS–III) working memory and processing speed index scores and did not produce

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Address correspondence to Rex L. Cannon, PhD, Cole Neuroscience Center: Memory Disorders Clinic, Suite 102, Building B., University of Tennessee Graduate School of Medicine, Knoxville, TN 37920, USA. E-mail: rcannon2@utk.edu

any reported negative effects (Cannon, Congedo, et al., 2009; Cannon et al., 2007). The negligible adverse effects also applied to six participants training low-beta power in the left and right prefrontal cortices.

From this point on we continued with the low-beta protocol in the cognitive division of the AC and modifications to other regions of training based on known functional magnetic resonance imaging and quantitative electroencephalography (qEEG) signatures. It is worth noting that all individuals who participate in these studies undergo an initial qEEG for evaluation and qEEG is monitored and analyzed across sessions for the duration of training. We trained a female recovering substance abuser to increase low-beta power in the right AC. We did not perform pre- and postcognitive tests. However, the individual was able to learn to increase the trained frequency with reports of minor headache at Sessions 3 and 8. She completed 25 sessions with no further reports of adverse or odd effects. During the training with this participant, the therapist or technician left the room during the training sessions and returned for post baselines (Cannon, Lubar, Sokhadze, & Baldwin, 2008). The linear trend for this participant was not as robust as the training with the technician present. It may be that this clinical case is simply different from normative individuals. However, in another study, clinical subjects did produce robust learning curves in the AC with the technician present. This potential therapist effect certainly warrants further investigation. We performed low-beta training in the cognitive division of the AC in monozygotic twins concordant with attention deficit hyperactivity disorder (ADHD; Cannon, Baldwin, & Lubar, 2009). Although both individuals were able to learn to increase low-beta power in the AC, network convergence was not achieved. We believe this reflects both dysfunction in the AC and disruptions in the insula as well as parietal cortices specific to the default network. Of interest, despite the learning curve shown in current source density, the network assemblage accounting for most of the variance in these twins was found in the left parietal region. This was an unexpected finding, given the prevalence of frontal dysfunctions associated with ADHD in currently available scientific literature. However, research does support the interaction between parietal and frontal activity in specific frequency domains. This network convergence is discussed in more depth elsewhere (Cannon, 2012).

Recently, we sought to influence positive changes in executive functions and self-regulation by employing LORETA neurofeedback training in the precuneus. The study was not designed to address any specific syndrome or diagnostic condition. Therefore we had both normal individuals and those with comorbid diagnoses (e.g., substance use disorder [SUD], substance use disorder in remission, ADHD, major depressive disorder, generalized anxiety disorder, and bipolar disorder). Of the trainings conducted to date, training in the precuneus has produced some of the more interesting effects. First, in children with ADHD (inattentive and combined types), those who were taking stimulant medications showed increased irritability and aggression after five to eight sessions as reported by parents. Similarly, the children reported rather severe headaches prior to sessions, but not after. Any time headaches were reported, the individuals were referred back to the pediatrician or psychiatrist for medications or evaluations. With the reduction or removal of medication there was a diminution of headaches, irritability, and aggression. In all participants, normal and otherwise, between Sessions 7 and 10, a difficulty in word finding was reported. This was temporary for all but more pronounced and noticeable by participants with SUD. For those adults with ADHD who were taking medications, the aggression and irritability was also reported between Session 5 and 8. After reduction or discontinuation of stimulant medications by physician or psychiatrist, these symptoms diminished. Headaches were reported at some point during the training for those individuals on any type of psychiatric medications, whether antidepressant or stimulant, between Sessions 3 and 8. The reasons for this effect are not known. However, network analyses may reveal significant effects in limbic regions that might be contributing to these reports. Given the complex connectivity of the precuneus to the brain stem, thalamus, and limbic regions, several potentialities for these effects exist and will be investigated (Castellanos et al., 2008; Cavanna & Trimble, 2006; Fransson & Marrelec, 2008; Luber et al., 2007; Wenderoth, Debaere, Sunaert, & Swinnen, 2005).

Several positive reports for participants in the frontal regions included clarity of thought, reduced anxiety, and increased focus. One of the individuals described himself as ''focusing on being focused.'' In retrospect, it would have been beneficial to examine both executive functions and personality measures, in addition to the WAIS scores. This is a goal for future studies. The precuneus has produced some of the more dramatic and noticeable positive effects (manuscript in preparation). These include self-reported improved sleep quality, increased energy levels, and increased ability to focus attention. The individuals reported less negative internal self-talk as well as increased positive interactions with others. The training produced significant changes in verbal fluency and color-word interference tasks of the Delis-Kaplan Executive Function System in both children and adults and a significant reduction in eight of the psychopathological scales of the Personality Assessment Inventory (Cannon, Baldwin, Di Loreto, & Khadoumma, 2011). We also had every participant maintain a daily journal to record mental strategies used during the training as well as recording any issues with sleep, attention, headache, or other experiences. Similarly, the IVA+ was used pre and post for certain participants, and significant changes as a result of LNFB were found. We are monitoring these individuals at 30 days and 6 months, and to date no adverse effects have been noted.

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