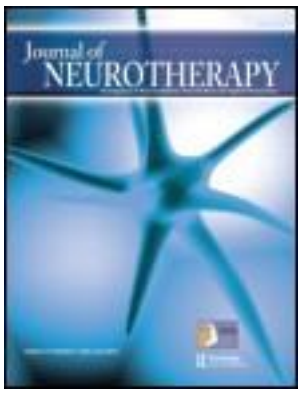

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SELECTED ABSTRACTS OF CONFERENCE PRESENTATIONS AT THE 2012 INTERNATIONAL SOCIETY FOR NEUROFEEDBACK AND RESEARCH (ISNR) 20TH ISNR CONFERENCE, ORLANDO, FLORIDA

STUDENT SCHOLARSHIP

LORETA Neurofeedback: Linking Self-Regulation and Anxiety

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Introduction

Anxiety is best conceptualized as a future-oriented, cognitive-affective somatic state, the prominent feature being ''a sense of uncontrollability focused on possible future threat, danger, or other upcoming, potentially negative events'' (Barlow, Chorpita, & Turovsky, 1996, p. 253). It is characterized by a sustained hyperarousal or heightened apprehension and vigilance to temporally uncertain, usually distal, danger. Behaviorally, anxiety is associated with avoidance. We propose a hypothesis that implicates disruptions in functional integration of neural networks important to self-regulation.

Methods

For the current study, 6 (4 male) participants with a prior diagnosis of anxiety or anxiety with a comorbid syndrome completed between 15 and 20 sessions of spatial specific EEG operant conditioning (LORETA Neurofeedback) to improve self-regulation.

Results

All participants were able to produce significant learning effects across sessions, including network convergent learning. Posttraining assessment discovered significant decreases in anxiety as measured by the Personality Assessment Inventory and significant increases in executive functions as measured with subtests from the Delis-Kaplan Executive Function System.

Discussion

Functional correlations between neurological and behavioral data demonstrate specific network involvement in these symptom reductions and provide data to develop a potential intervention for anxiety disorders in 20 days or less.

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INVITED PRESENTATION

Neurotoxins: Effects on Brain and Behavior and Therapy

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Since the middle of the 20th century, the rapid proliferation of chemical compounds used in the environment, medical treatment, and alternative methods used for food production have led to grave concerns about the potential effects of these compounds and their resultants on the efficiency of the electrochemical workings of the human brain and its development. Some of these concerns were published in the popular media in mid–20th

century by such authors as Rachel Carson in her now-famous nonfunctional work *Silent Spring* and from publications resulting from the United Nations Environment Programme initiated by U Thant, third Secretary-General of the United Nations. However, it wasn't until the rise of large-scale lawsuits against the offending industries coupled with the near epidemic rise of health problems in the late 1980s and into the 21st century involving neurocognitive and neuromuscular disorders that there has been a global interest in this domain. This presentation provides an overview of the types of neurotoxic intrusions currently present that are likely involving not only health risks in general along with their associated economic factors but the functionality of humans to be adaptive and optimally functional in an increasing complex and demanding world for cognitive performance efficiency. Examples of studies are provided to illustrate the effects of exposure to metallotoxins and lipophilic toxins and the cascading changes of biochemical processes ultimately impacting on physiological efficiencies and alterations in the ways cell assemblies in the brain are modified leading to alterations in behavior and adaptive capabilities. Discussion is also provided on how these effects not only significantly impact the ways we assess and treat conditions of aberrant human behavior but also have implications on the potential limits with neurotherapies attempting to compensate for central nervous system functional inefficiencies.

KEYNOTE PRESENTATION

Effects of Non-Pharmacological Pain Treatment on Brain States

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Chronic pain is a significant problem for many individuals, and available treatments are often inadequate. Noninvasive neuromodulatory treatments, such as neurofeedback (NF), have the potential to benefit individuals with chronic pain. However, little research has examined the neurophysiological mechanisms of these treatments. Knowledge concerning these mechanisms is critical for knowing how to develop effective interventions. To address this knowledge gap, 31 individuals with spinal cord injury and chronic pain were given single 20-min sessions of 4 neuromodulation procedures (meditation, hypnosis, a NF protocol reinforcing alpha and inhibiting beta activity at T3 and T4, and transcranial direct current stimulation [tDCS]), as well as a single session of sham tDCS, in random order. EEG activity and pain intensity were assessed just before and just after each session. We predicted that (a) the procedures would result in significant decreases in pain, (b) the procedures would result in changes in EEG activity, and (c) pre- to postsession changes in EEG activity would be associated with decreases in pain intensity. Exploratory analyses allowed us to determine whether (a) any pain-related changes in EEG activity found were global (i.e., similar across many electrode sites) or site specific, (b) the different procedures had similar or different effects on EEG (indicating similar or different mechanisms, respectively), and (c) presession EEG activity predicts treatment response. All of the procedures had immediate effects on EEG activity, two of the procedures (hypnosis and mediation) had significant immediate effects on pain intensity, and a third (tDCS) showed a nonsignificant trend to decrease pain for participants in neuropathic pain. However, (a) each procedure had different effects on EEG; (b) other than some indication that *any* change in T3 activity was associated with improvements in pain, the bandwidths, and electrode sites associated with treatment response were not consistent across the procedures; (c) the patterns associated with outcome and changes in pain differed as a function of pain type; and (d) different presession EEG patterns were was associated with treatment response that was different for each procedure. The findings indicate that (a) different neuromodulatory treatments have different mechanisms for producing pain relief and (b) there is no clear EEG activity pattern associated with

greater pain relief—these treatments may work because they produce a *change* in activity rather than a change in specific bandwidths at specific sites. Given that NF training is known to alter EEG activity, the findings support NF as a potential treatment of refractory pain. If the current findings were to replicate in additional samples, they suggest that NF clinicians treating pain should (a) consider including the T3 site in training; (b) tailor treatment to each patient's pain condition; and (c) think in terms of interrupting/changing activity patterns (for pain treatment), perhaps using training protocols that improve comorbid symptoms (e.g., cognitive performance, mood, sleep quality) to maximize treatment benefits.

POSTER

Logic: A Pain in the Anterior Cingulate

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Introduction

This study utilized quantitative EEG and LORETA source localization, alongside hypothalamic-pituitary-adrenal (HPA) axis activity to facilitate real-time inquiry into active, cortical regions of interest and stress reactivity associated with logic and deductive reasoning. To date, functional connectivity and neuronal and stress hormone cortisol activity underlying logic and deduction remain unclear.

Methods

Eighteen study participants between the ages of 18 and 50 participated in this study. Subjects underwent continuous EEG recording in 4 conditions (eyes-closed and eyes-open baselines, learning [priming], and syllogism validation). Pre- and postsalivary cortisol sampling baselines were collected before and after said experimental condition. Subject responses were marked within the EEG record, extrapolated, and compared for significance using standardized low-resolution electromagnetic tomography for 6,329 5 mm^3 voxels.

Results

Previous research and statistical analyses, without cortisol measures, revealed current source density supporting evaluation processes in deduction were specific to the left hemisphere, Brodmann area (BA) 30, parahippocampal gyrus, and anterior cingulate and activity in the right frontal lobe regarding the beta frequency. Decisions compared to instruction (learning) produced increases in all frequency domains in various cortical regions. Delta frequency showed increase in BA 10 and a distributed pattern in the cingulate gyrus. Theta showed maximal increases at BA 10 and the anterior cingulate (BA 32), as well as right BA 18, 19, 37, and 40. Alpha frequency showed increase in the left temporal and posterior cingulate (i.e., may reflect language processing and semantics). Beta was increased in BA 19 (precuneus) and decreased in anterior regions.

Discussion

This study utilized a repeated measures design to analyze the underlying relationship between cortical activity and functional connectivity, along with HPA axis stress hormone cortisol reactivity associated with logic. Plausible interpretation of the data may denote the importance of low-frequency bands and/or stress in information retrieval and network integration of syntax, semantics, and other executive processes as a function of deductive inference decision making in the anterior cingulate, prefrontal cortex, and posterior cingulate cortex.

POSTER

On the Differences Between Topographical and LORETA Neurofeedback in Children and Adults

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Introduction

This study distinguishes between the effects of a recently developed α-protocol designed for improvements in self-regulation and LORETA neurofeedback training of the α-frequency in the precuneus with the same function. Concentration of both protocols is in the left parieto-occipital cortex.

Methods

This study consists of 6 children and 4 adults with attention deficit/hyperactivity disorder who received 20 sessions of the alpha protocol 2 or 3 times per week contrasted with 2 age-similar children and age-similar adults who underwent the LNFB protocol over 15 to 20 consecutive weekdays.

Results

There are similarities and differences specific to each protocol, with LNFB appearing to influence specific networks in a more definite fashion. Such disparities appear in fronto-parietal regions with global differences noted.

Discussion

Neurofeedback, in general, operates under the auspices of neuroplasticity and a neural efficiency model. Differences between topographical and LORETA neurofeedback exist and should be investigated; yet there are numerous similarities as well. Clinical and research applications are discussed.

ORAL PRESENTATION

Biomarkers of Neurological and Psychiatric Dysfunctions: Clinical Applications for Diagnosis and Treatment

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In the first part, the article reviews studies of event related potentials (ERPs) in the normal and diseased brain. It is shown that the ERP negative and positive fluctuations such as N1, mismatch negativity, and N2 waves as well as various P300 waves could be considered as biomarkers of neurological and psychiatric conditions. Indeed these indices of information flow in the cortex (a) have high test–retest reliability; (b) consistently reflect experimental manipulations in stimulus, sensory, and emotional modality, probability, behavioral meaning, and so on; and (c) are associated with executive functions such as action selection, action preparation, action suppression, and monitoring conflict between competing actions. The ERP waves discriminate a selected psychiatric condition from a healthy population with quite large effect sizes. However, the majority of ERP waves appear to be not single entities but can be further decomposed into separate components with distinct functional meanings. At the same time, each psychiatric disease appears to be characterized by multiple dysfunctions in complex brain systems and, consequently, must be indexed by multiple ERP components obtained in different behavioral paradigms. The second part of the article deals with new methodological approaches that have emerged recently to overcome these hurdles in ERP clinical application. They are (a) independent components analysis-based ERP decomposition into separate functionally meaningful components, (b) nonparametric methods for mapping generators of ERP components into 3D tomograms, and (c) appearance of an ERP normative database. The third part of the article presents our own studies on the application of the Human Brain Index database for discriminating different psychiatric groups from healthy controls as well as for designing protocols for treatment of the corresponding brain dysfunctions.

ORAL PRESENTATION

In Search of Depression

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Introduction

The *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text rev.; American

Psychiatric Association, 2000) proposes that patients suffering from major depressive disorder will display state-dependent irregularities during examination by electroencephalogram and other experimental methods. This study sought to capture this state dependency by utilizing topographical EEG and connectivity and LORETA current source density in the alpha frequency domain that would differ between groups as would pre–post task salivary cortisol levels.

Methods

This study was conducted with 23 (13 with depression) participants, 16 female with a mean age of 20 ± 2.45 years. Depressed individuals had received a diagnosis of depression within the past year. We administered the Clinical Interview for DSM-III-R (SCID–R) to the depressed group. We collected salivary cortisol prior to any experimental conditions. Participants then provided 4-min eyes-closed and eyes-opened baseline EEG recordings. The participants then completed the Beck Depression Inventory while the EEG was continuously recorded. Items were presented for 8 s in Microsoft PowerPoint, and responses were marked within the EEG record. These segments were extrapolated and compared for significance within and between groups. Postsession cortisol levels were collected and analyzed.

Results

Minimal differences are seen between depressed and nonclinical groups for topographical absolute and relative power. Significant differences were found in asymmetry, coherence, and phase measures between groups. Current source density in alpha differs between groups with the depressed group showing specific regional increases in right prefrontal regions. Notably, cortisol decreased relative to the BDI task in all subjects, with differences still evident between groups.

Discussion

As with many other studies, topographical power differences are sparse. Connectivity and LORETA current source density measures do reveal significant differences between groups and may provide a more accurate method for differential diagnosis of depressive disorder. Several studies have reported blunted cortisol responsivity in depression relative to stressors, and our data appear to follow these results. Diagnostic, research, and clinical implications are discussed.

POSTER

Infra-Low-Frequency Neurofeedback: Results of a School-Based Pilot Program

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Infra-Low-Frequency (ILF) neurofeedback is a new paradigm in biofeedback training that is generating interest among practitioners due to clinical reports of its efficacy with a wide range of client presentations. This poster presentation reports on an ILF neurofeedback pilot program in a special needs school in New York City. Preliminary results from that program include pre- and post-CBCL and ATEC scales in additional to clinical reports. *Results of Pilot School Program:* In total, we have had 16 students in the program. Thirteen of the 16 students had a positive response that involved a significant reduction of tantrum behavior and/or a reduction or elimination of psychotropic medication and/or improved ability to sustain attention during class resulting in academic progress. Of the remaining 3 students, 2 have just begun the program and 1 had a positive response that is confounded by the initiation of a selective serotonin reuptake inhibitor (SSRI) at the beginning of the training. This subject, a selectively mute child, achieved a remarkable improvement in symptoms after approximately 1 week on the SSRI and 2 weeks with neurofeedback. In addition to presenting the behavioral data obtained from the school-based program, the poster presents pre- and post-quantitative EEGs (QEEGs) for individuals who have undergone ILF treatment.

Recent equipment and software advancements have allowed for simultaneous 19-channel recording and ILF training. This innovation has provided a window on the mechanism of bipolar ILF training. The value of QEEG in predicting treatment responders, treatment planning, and determining treatment outcomes is discussed. We also outline some proposed mechanisms of action for ILF neurofeedback and propose a research design for uncovering the mechanism.

ORAL PRESENTATION

Neurofeedback Protocol for the Treatment of Phonetic and Expressive Speech Impairments: Report of Two Cases

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Background

We report treatment results of 2 children, 6 and 5 years old, diagnosed with severe Phonetic and Expressive Language Impairments since they were 2 years old. They failed to develop language with no diagnoses of slow development syndrome, physical abnormalities of the speech apparatus, autistic disorder, acquired or genetic brain or neural damage, hearing loss, or oral motor deficits, and they have proper strength, coordination, range of movement, symmetry, and speed of cranial nerves V, VII, IX, X and XII. They exhibit poor performance in the school and have hearing test results of 25 dB, nonverbal IQs of 90, lower verbal IQs, and no emotional disturbances. Their speech is not fluent and is characterized by a 20-word repertoire, short phrases, word omissions, and poor comprehension of language in general.

Methods

Evaluations results revealed that the patients exhibited 85% Delta/Theta (1–7 Hz) prevalence over 15% Beta1 (15–18 Hz) with eyes open. Patients received 40 sessions of neurofeedback treatment (3 sessions weekly) using an I-330 C2 + 6 Neuro/Biofeedback system with USE3 software (J&J Engineering, Poulsbo, WA). They trained to increased Beta1 and decreased Delta/Theta and EMG (40–360 Hz) at T4/C4 and P3/F7 derivations simultaneously. Neurofeedback reward stimuli were auditory and visual.

Results

Beta1 prevalence increased to 40% while Delta/Theta decreased to 60% and EMG decreased to 10%. After the 2nd week of treatment, school staff and parents reported general improvement in phonetic and expressive speech and language skills, incremental improvement in verbal repertoire, which increased to more than 100 words, more fluent speech, development of more accurate written language, and improvement in school performance. Results persisted at follow-up, which occurred at 1 and 3 years posttreatment.

Conclusions

Findings suggest that induction of brain activity integration at T4/C4 and an incremental increase in Beta1 in the left hemisphere at P3/F7 lead to appropriate speech development and strongly suggest a need to replicate findings with a larger group to develop standardized treatment protocols.

STUDENT SCHOLARSHIP

Investigation of Unspecific Placebo Effects in Slow Cortical Potential Neurofeedback for Adult Attention-Deficit/Hyperactivity Disorder

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Objectives

Neurofeedback has been applied effectively in various areas, especially in the treatment of children with attention-deficit/hyperactivity disorder (ADHD; Arns, De Ridder, Strehl,

Breteler, & Coenen, 2009). However, unspecific treatment effects like expectations and patient–therapist relationship may have an influence on therapy outcome. These unspecific effects are usually hard to control for without placebo or waiting groups (Gevensleben, Rothenberger, Moll, & Heinrich, 2012). This study investigates slow cortical potentials (SCP) neurofeedback training for ADHD and its possible unspecific effects assessed via a self-rated placebo questionnaire (Vollmann, Hautzinger, & Strehl, 2009).

Methods

Twenty adult participants with ADHD received 30 sessions of SCP neurofeedback training at Cz (referenced to A1, grounded at A2; see Mayer, Wyckoff, Schulz, & Strehl (2012) for the methods). Every 5th session participants filled in the German questionnaire ''Fragebogen zur Erfassung relevanter Therapiebedingungen'' (FERT), which is a self-rated questionnaire to assess relevant treatment conditions, patient expectations, and patient–therapist interactions (Vollmann et al., 2009). The FERT was analyzed for expectation changes over the course of the neurofeedback training as well as used as a covariant in the analysis of training performance and symptom changes.

Results

This investigation is in progress. The expected changes over the course of the feedback, the correlations between FERT and training performance, and the symptom changes will be presented at the time of the conference.

Conclusion

Possible placebo effects have always been a concern in neurofeedback. Correlations may yield valuable findings about the impact of unspecific effects on neurofeedback. Study limitations and future directions in research will be addressed.

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ORAL PRESENTATION

Combining Neuroeconomics with LORETA Biofeedback to Improve Self-Control and Promote Healthy Behavior

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Background

What occurs in the brain when a person foregoes a decadent dessert and instead chooses a food that is healthy but bland? The field of neuroeconomics has begun to answer this question. Neuroeconomists have elucidated some of the neurophysiology that allows people to save rather than spend, to choose the gym over the couch, and to eat carrots rather than cookies. Researchers have identified neural mechanisms that may underlie self-control, but they have not applied this knowledge to develop tools for improving self-control ability. LORETA biofeedback (LB) may allow us to harness

neuroeconomics findings in order to develop interventions for improving self-control. We define self-controlled behaviors simply as those in which large delayed rewards are chosen over smaller immediate rewards. Building on the neuroeconomics literature, we have developed an LB protocol designed to strengthen the neurophysiology underlying self-control. This protocol may improve self-control ability, and thereby increase an individual's capacity to exhibit heath behaviors for which self-control is required (e.g., dieting and exercising). LB may therefore offer a novel approach to health behavior promotion.

Methods

A randomized, controlled, single-blind study was conducted to assess the effects of the LB protocol on self-control. Subjects attended 4 study sessions on 4 consecutive days. A self-control task involving food choice was administered during the first and last sessions. Subjects rated a series of foods on health and taste; subjects then chose between foods they had rated as bland-but-healthy and foods rated as tasty-but-unhealthy. Self-control was defined as choosing bland-but-healthy foods over tasty-but-unhealthy foods. Between the two administrations of the self-control food choice task, treatment group subjects completed the LB protocol that was designed to improve self-control. This protocol, which was tailored for each subject, involved targeting the following regions of interest: right dorsolateral prefrontal cortex (dlPFC), left dlPFC, dorsal anterior cingulate cortex, and left supplementary motor area. Control subjects completed an LB protocol that was expected to have no effect on self-control performance. Logistic multilevel modeling was used to compare changes over time in self-control performance of the treatment group to those of the control group.

Results

Eighty-five percent of sessions have been completed; results from the full study sample will be reported at the conference presentation. In our current dataset, a significant Time × Condition interaction is observed ($p < .01$). Consistent with predictions, self-control performance of the control group significantly decreased over time ($p < .01$), whereas that of the treatment group did not change over time ($p > .5$).

Discussion

Preliminary results suggest that LB may be useful for preventing reductions in self-control over time; LB may therefore offer a novel approach to health behavior promotion. Additional research is needed to determine whether these results—which were observed solely in the laboratory—can be replicated in real-world contexts.

INVITED PRESENTATION

Comparison of the Effectiveness of *Z*-Score Surface/LORETA 19-Electrodes Neurofeedback to Standard 1-Electrode Neurofeedback

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The effectiveness of *Z*-score surface and low-resolution electromagnetic tomography analysis (LORETA) Neurofeedback (NFB) has been retrospectively compared to standard (1-electrode) NFB treatment. This is multicase report based on the analysis of 40 patients from a solo neurology practice who either reported improvement of symptoms with *Z*-score NFB or completed at least 10 *Z*-score (surface/LORETA) sessions. The analysis included subjective (self-reported) and objective (quantitative electroencephalography [QEEG], computerized neuropsychological testing) responses to NFB therapy. QEEG and computerized neurocognitive testing (in selected patients) were completed before and after NFB treatment and analyzed for any major changes in frequency band expression or an improvement in a cognitive function. *Z*-score surface/LORETA NFB patients were divided into four groups: patients suffering from headaches (frequently with anxiety and/or

chronic pain), cognitive problems, behavioral problems, and focal neurological disorders (stroke, epilepsy). The average *Z*-score NFB number of sessions per patient was 9 (range = 3–24). Analysis of patients' reports revealed 95% subjective improvement rate and 62.5% objective QEEG improvement rate after *Z*-score NFB therapy. These results were retrospectively compared to 25 patients who were treated in the same practice using a standard 1-electrode NFB technique and completed in at least 20 sessions with 84% of subjective improvement rate and 75% objective QEEG improvement rate. These results indicate similar effectiveness of *Z*-score NFB and 1-electrode standard NFB in achieving positive response to EEG biofeedback. However *Z*-score NFB seems to have higher potency because many patients required fewer sessions to achieve a desirable subjective response. Therefore, *Z*-score NFB application may contribute to increase patient compliance and may offer a more cost-effective treatment. Several cases of marked improvement with *Z*-score NFB treatment are discussed, including a patient with intractable epilepsy and subsequent complete normalization of epileptiform EEG with NFB therapy. Also, 2 cases of major cognitive enhancement including improved verbal function and information processing speed are presented.

ORAL PRESENTATION

Enhancing Neurotherapy by Means of Brainstem Activation Through Primary-Reflex Rhythmic Movements

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Piaget argued that the ''sensorimotor stage'' is the first stage of development, facilitating all cognitive functions. Hebb proposed that neural structures, which he termed ''cell assemblies,'' constituted the material basis of mental concepts. Rita Levi-Montalcini discovered nerve growth factors that cause axonal growth. Michael Merzenich argued that, ''The key in developing exercises is to give the brain the right stimuli in the right order with the right timing to drive plastic change.'' Norman Doidge (2007) concluded, ''Many *'circuits' and even basic reflexes that we think are hard-wired are not*'' (p. xv). Neurologists agree that the lack of inhibition (or integration) of primary reflexes and lack of brain development are the causes of developmental delays and other mental problems. Such a disruption interferes not only with the brainstem functions but also with the basal ganglia-cerebellum networking and cortical processing, thus affecting learning, movement and attention. What is less known is how to reactivate these reflexes in order to ease their integration with rhythmic movements that gives brain maturity a ''second chance,'' ''rebooting the brain software.'' This session introduces the concept of a ''bottom-up approach'' (from brainstem to midbrain to cortex). For the past 20 years, the author has witnessed significant improvements in her clients as she teaches her clients these movements as an initial intervention before adding neurofeedback training. Case studies using quantitative electroencephalography, academic performance, and continuous performance data will be provided to support the validity of using primary-reflex rhythmic movements as a viable adjunct intervention to neurofeedback.

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ORAL PRESENTATION

Real-Time Functional Magnetic Resonance Imaging Neurofeedback to Attain Volitional Control Over Brain Activity and Associated Mental Functions: A Systematic Review

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Background

Technical advances have allowed processing functional magnetic resonance imaging (fMRI) data in real-time (RT; Cox, Jesmanowicz, & Hyde, 1995), enabling its use for neurofeedback (NF) applications (Posse et al., 2003; Weiskopf et al., 2003; Yoo & Jolesz, 2002). This opened the way to conduct studies aiming at modulating brain activity and associated mental processes by RT-fMRI-NF, based on accumulated knowledge on brain activity related to mental functions (Caria, Sitaram, & Birbaumer, 2011; Weiskopf, 2011). We present here the first systematic review on RT-fMRI-NF for volitional control attainment.

Method

We identified articles on the use of RT-fMRI-NF to attain volitional control over brain activity in humans by a systematic search in several scientific databases (Medline, Embase, PsycINFO, Web of Science). Two independent reviewers extracted relevant information. We assessed the study quality of the identified articles and quantitatively integrated the results. The systematic review was conducted in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009).

Results

Nearly all identified studies reported that RT-fMRI-NF was associated with attainment of volitional control over hemodynamic brain activity, which was more pronounced than in control conditions (such as sham feedback, if included in the study design). Moreover, attainment of volitional control was mostly associated with modulation of mental functions or symptom improvement (e.g., DeCharms et al., 2005). However, the identified studies substantially varied in study and reporting quality.

Conclusion

The accumulated body of evidence suggests that RT-fMRI-NF can be used to attain volitional control over hemodynamic brain activity (and most likely associated neuronal activity), and thereby over associated mental functions. However, high-quality studies, including randomized controlled trials, are highly warranted. Based on the reviewed articles, we suggest a gold standard for conducting and reporting high-quality RT-fMRI-NF studies.

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STUDENT SCHOLARSHIP

The Dynamics of Brain Networks Involved in Deep Relaxation Regulation Guided By EEG Neurofeedback

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Introduction

A common protocol of EEG-NF training aims to guide people via a closed-loop operation shifting from high-amplitude of alpha (8–14 Hz) to high amplitude of theta (4–7 Hz) oscillations resulting in greater theta/alpha ratio (T/A; Vogel, Foulkes, & Trosman, 1966). The induction of such a shift in EEG oscillations has been shown to be useful in reaching a state of relaxation (Peniston, Marrinan, Deming, & Kulkosky, 1993). However, the clinical implication of this practice in psychiatry remained elusive and considered of relatively low therapeutic yield (Gevensleben et al., 2009; Lantz & Sterman, 1988), possibly due to its widespread cortical representations. The current project aims to use simultaneous acquisition of Functional Magnetic Resonance Imaging (fMRI) and EEG in order to unfold in high spatial and temporal resolutions, respectively, the neural modulations of the mental state of relaxation induced via T/A EEG-NF. We used signal characteristics and temporal modulation of theta and alpha for revealing the dynamics of brain network related to the relaxation process. Three main networks were revealed, including cortical and deep limbic brain structures. The first neural network involved in motor inhibition, the second in managing relaxation, and the third in relaxation stabilization. We presume that better understanding of the neural mechanism underlying the T/A NF process might help to optimize the neurofeedback procedure at the individual level and thus will increase its specificity per mental condition.

Methods

Fifty healthy subjects participated in a prescanning 15-min training with eyes closed to apply EEG neurofeedback for increasing the ratio of theta to alpha. In the 3 T MRI scanner subjects followed a similar EEG neurofeedback protocol twice. BrainVoyager, EEG-Lab, and at-home software packages were used for preprocessing and analyzing the raw brain signals in correspondence to induced mental states.

Analysis and Results

A data-driven algorithm implemented in Matlab Mathworks (Framingham, MA) employed the criteria of T/A power increase above 1 (''crossover'') for more than one third of the scan to classify each subject's scan as a responder to the NF procedure, or otherwise as a nonresponder. A general linear model for the whole brain using the modulating power of theta, alpha, and the theta/alpha ratio as predictors was calculated. Defined contrast between responders and nonresponders for each of the bands revealed 3 main networks involved in the mental dynamics of deep relaxation. The first revealed the motor inhibition network (i.e., bilateral cerebellum, right BA47, and left caudate). The second is related to relaxation management (i.e., dorsal medial prefrontal, thalamus and putamen), and the third related to the relaxation stabilization (Insula and ventral anterior cingulate).

Conclusions

Simultaneous fMRI during EEG feedback via alpha/theta ratio modulation probed activation variation in brain networks related to the mental process of deep relaxation. The use of the modulation and characteristics of the bands used in the NF procedure revealed the brain networks involved in deep relaxation. Altogether our results clearly demonstrate the advantage in combining EEG NF and fMRI for unfolding the brain mechanism underlying mental states. Methodological and practical

aspects of such an approach are further discussed.

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STUDENT SCHOLARSHIP

Single Trial Time-Frequency Domain Analysis of Error Processing in Post-Traumatic Stress Disorder

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Introduction

Posttraumatic stress disorder (PTSD) causes deficiencies in the error-processing system. Electroencephalography (EEG) recordings of individuals with PTSD are often used to study error monitoring and correction deficits. Traditionally, many error trials are collected during a task with EEG systems and averaged together to obtain an estimate of a measure known as an event-related potential (ERP). Two ERPs are often used to study error processing, those being the error-related negativity and positivity (ERN and Pe; Sokhadze et al., 2008; Yeung & Cohen, 2006). We have developed an alternate time-frequency domain single-trial analysis technique to assist in analyzing data sets with low numbers of error trials and examining the contribution that single-error trials make in PTSD.

Methods

A wavelet transform of the single trial information collected from PTSD subjects ($n = 10$) and controls ($n = 10$) during an Eriksen flanker test was carried out using a custom MATLAB script. A measure of the ERN and Pe in the time-frequency domain (time-frequency ERN and Pe) was found in each single trial using a wavelet transform, and statistical analysis was carried out to determine if any significant differences between groups in latency or amplitude of the time-frequency measures were present. Behavioral analysis was also conducted.

Results

It was found that the PTSD group exhibited attenuated time-frequency ERN and Pe amplitudes as compared to the controls. Specifically, they exhibited less negative amplitudes in the time-frequency ERN and less positive amplitudes in the time-frequency Pe. Behavioral deficiencies such as slower reaction time and lower accuracy of responses were also revealed in the PTSD group.

Discussion

The averaging process to obtain the ERN and Pe can be difficult if not enough error trials are present in the data collection and can destroy information in the single-trial recordings. To rectify this, we developed a new method of measuring single-trial error trials in the time-frequency domain using a wavelet analysis technique. It was shown that this analysis technique was able to differentiate the between the single-trial errors of the control group and PTSD group. The differences in the time-frequency ERN and Pe amplitudes found were posited to occur due to the hypofunctionality of the anterior cingulate cortex in the PTSD group (Woodward et al., 2006).

Conclusion

The time-frequency domain analysis technique can be used to find single-trial error differences in the time-frequency ERN and Pe measure of a control and PTSD population.

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STUDENT SCHOLARSHIP

An Event-Related Potential Study of Visual Spatial Attention Deficits in Autism

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Background and Aims

Along with other frontal executive function deficits, individuals with autism present abnormalities of spatial attention orienting. The proposed study aims to understand the abnormal neural and functional mechanisms underlying attention abnormalities in autism by incorporating event-related potential (ERP) and behavioral measures of visuo-spatial attention (Di Russo, Martinez, & Hillyard, 2003; Gomez-Gonzales, Clark, Luck, & Hillyard, 1994). The aim of the study was to investigate between group (autism vs. controls) differences in behavioral responses and frontal and centro-parietal ERPs in a cued Posner spatial attention paradigm (Posner, Cohen, & Rafal, 1982).

Methods

Participants for the study were recruited from the pool of individuals with autism spectrum disorder (ASD) at the Weisskopf Child Evaluation Center at the University of Louisville. From 30 screened ASD patients, 21 were high-functioning individuals with an autism diagnosis who complied with ERP task requirements and tolerated dense-array EEG recording. Mean age of subjects was 15.5 ± 5.2 years, 6 of them female. Nineteen typically developing children were recruited by advertisement and screened to rule out history of any psychiatric or neurological disorders. Mean age of control group was 16.2 ± 4.1 years (7 female). The spatial attention task was programmed in E-Prime (Psychology Software Tools, PA) and represented a modification of a cued Posner spatial attention task. The task had 2 blocks—1 with horizontal windows and the second with diagonal windows where the target appeared either at the left or the right side of the screen. The probability of correctly cued congruent targets was 80% in both blocks. EEGs were recorded on a 128-channel Electrical Geodesics Inc. system (Eugene, OR). The task took 20 min to complete, including a practice block. The ERP of interest included early (N100, P200) and late (N200, P300) components at the frontal and centro-parietal areas reflecting spatial attention processes. The analysis included comparison of behavioral performance (reaction time, accuracy, number of omission, and commission errors) and ERP measures. In addition to the second cue stimulus (S2) locked ERPs, we also analyzed lateralized readiness potential (LRP) recorded as a difference wave between responses at the motor strip (C3/C4) starting from the first cue (precue S1; Leuthold, 2003). The ERP data set was analyzed using analysis of variance with within-subject factors (Cue Position [Horizontal, Diagonal], S1 Cue Congruence [valid, invalid], and Hemisphere [left, right]) and a between-group factor (Group [Autism, Controls]).

Results

Reaction time (RT) analysis showed a Congruence × Group effect ($F = 7.14$, $p = .011$); in particular, the ASD group had similarly slower RT both in valid and invalid precued conditions, whereas controls responded faster to correctly prompted targets. Accuracy of responses was lower in the ASD group ($F = 7.88$, $p = .008$), mostly due to a higher omission error rate ($F = 6.17$, $p = .017$). The midline frontal N100 component yielded a marginal Position × Congruence × Group interinteraction ($F = 4.14$, $p = .049$), where the ASD group had more negative N100 amplitude during the diagonal target condition regardless of congruence of cues. Furthermore, we found a significant Position × Congruence × Hemisphere × Group effect ($F = 4.52$, $p = .040$) where the above effect was more pronounced at the right hemisphere. Amplitude of the midline frontal N200 component showed a Position × Congruency × Group interaction ($F = 4.13$, $p = .045$). The group differences of peak latency for both N100 and N200 components were not significant. The centro-parietal P300 (P3b) component showed between group differences at the midline ($F = 5.38$, $p = .026$) and at the left hemisphere ($F = 4.80$, $p = .035$) in the invalidly cued diagonal target condition and was significantly prolonged in the ASD group. The amplitude of the LRP in the ASD group was lower and delayed as compared to the control group ($ps < .05$).

Discussion and Conclusions

Most of the ERP differences were observed at frontal sites, thus pointing at possible frontal executive deficits in autism. Children with autism had more impaired responses to diagonal targets requiring more spatial orienting capacity. Of particular interest for future studies are the frontal hemispheric differences present at the preattentive early processing stages (N100) and less discrimination between correctly and incorrectly cued targets at the later stages of processing. This was manifested in the enhanced frontal N200 component resulting in a delayed cognitive P3b potential (Polich & Herbst, 2003) in the autism group. We have found that using a cued Posner's spatial attention test and comparing the autistic patients' behavioral performance and ERPs can be a very informative approach to understanding the mechanisms of spatial orienting impairments and motor act preparation deficits typical of autism.

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KEYNOTE PRESENTATION

Self-Regulation in the Treatment of Chronic Heart Failure

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Biofeedback training can be used to control autonomic input to the cardiovascular system. It has been well-established in our laboratory and others that heart failure is accompanied by hyperactivation of the sympathetic nervous system, and decreasing sympathetic input with a beta blocker or left ventricular assist device

improves clinical status and also reverses cellular and molecular alterations associated with heart failure. We hypothesized that heart failure patients could be trained with biofeedback and that this method of regulating the sympathetic nervous system would also produce myocardial remodeling in the direction of recovery. To test this hypothesis, end-stage heart failure patients at the Cleveland Clinic were enrolled in a research study that included an initial assessment of psychophysiologic reactivity to mental stress, 6 sessions of biofeedback-mediated stress management training with a certified biofeedback therapist, and a final assessment of psychophysiologic reactivity to mental stress. Quality of life was also evaluated before and after biofeedback training using the SF-36 and Kansas City Cardiomyopathy questionnaires. Plasma norepinephrine and 6-min walk distance were measured before and after biofeedback training, as a marker of clinical status. After biofeedback training, at the time of heart transplantation, explanted hearts were transported to the laboratory to study the heart failure phenotype. Left ventricular trabecular muscles were dissected and studied in a tissue bath, measuring the inotropic response to sympathetic stimulation. A single dose of isoproterenol, a synthetic norepinephrine analogue, was used as an index of sympathetic nervous system recovery. Beta adrenergic receptors on myocardial cell membranes were also measured, using radioligand binding and Scatchard analysis. Preliminary data suggest that biofeedback produces remodeling of the heart failure phenotype, in the direction of normal, similar to what we have previously shown in hearts supported with a left ventricular assist device.

ORAL PRESENTATION

Comparing the Effects of Neurofeedback and Hyperbaric Oxygen Therapy in Autism Spectrum Disorder: A Case Series

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The prevalence of autism spectrum disorders (ASD) continues to rise at an alarming rate (Centers for Disease Control and Prevention, 2012). As a result, the need for empirically validated treatments and knowing which treatment works best for whom becomes all the more pressing. Due to a dearth of this knowledge, Green et al. (2006) have shown that most children with ASD utilized multiple treatments and there is no guide as to which treatment might work best. We present data on a comparison of two popular treatments for ASD with preliminary empirical support: neurofeedback (NF; Coben & Wagner, 2011) and Hyperbaric Oxygen Therapy (HBOT; Rossignol, Rossignol, James, Melnyk, & Mumper, 2007). After presenting information on the empirical support of these approaches, data are presented in a case series format. These data present symptom and neurophysiological (QEEG) changes derived from NF and HBOT delivered to separate patients with ASD. Last, A-B and A-B-A design data are presented for NF and HBOT that were administered to the same patients at different times. This gives us, for the first time, the ability to compare the effects of these treatments in the same patients. The findings suggest that, although HBOT can be helpful in certain cases, NF seems to help more often, has a greater effect, and is more specific in the changes that may be achieved. Clearly, more empirically based research is needed to confirm these findings.

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ORAL PRESENTATION

Combined Neuromodulation Method Aimed to Improve Frontal Functions in Autism

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Introduction

Among the emerging methods of neuromodulation such neurotherapeutic techniques as repetitive Transcranial Magnetic Stimulation (rTMS) and neurofeedback (NFB) are most promising for the treatment of core autism symptoms. TMS offers a noninvasive method for altering excitability of the neural circuits and induction of a short-term functional reorganization in the human cortex. Because effects of rTMS are not limited to the stimulated target cortex but give rise to functional changes in anatomically and functionally interconnected cortical areas, rTMS is a suitable tool to modulate neural plasticity within a distributed functional network. The rTMS may have therapeutic potential in some psychiatric disorders (e.g., depression; George et al., 1999). Recently, we reported positive therapeutic effects of low-frequency rTMS in autism spectrum disorders (ASD; Baruth et al., 2010; Sokhadze et al., 2012; Sokhadze et al., 2010; Sokhadze et al., 2009). The NFB is a form of operant conditioning of electroencephalographic (EEG) activity in which desired electrocortical activity is rewarded, whereas undesirable activity is inhibited. Positive effects of NFB training have been found and well documented for ADHD (Sherlin, Arns, Lubar, & Sokhadze, 2010). Less is known about the effects of neurofeedback-based intervention to sensory and cognitive functions in children with ASD (Coben, Linden, & Myers, 2010). There are not any studies yet reported where rTMS and neurofeedback are used as a combined neuromodulation approach to treat core symptoms of autism.

Goals

Autism is a pervasive developmental disorder of childhood characterized by deficits in social interaction and language, stereotyped behaviors, and restricted range of interests. The study is based on an underlying neuropathology model of autism that emphasizes minicolumnar pathology (Casanova, 2007; Casanova et al., 2006) and lateral inhibition deficits resulting in behavioral, executive, and emotional dysfunctions. We propose that neuromodulation based on low-frequency rTMS will enhance lateral inhibition through activation of inhibitory double bouquet interneurons and will be accompanied by improvements in prefrontal executive functions. The numerous studies of effects of TMS agree that most profound acute effects of magnetic stimulation last for approximately 1 hr, whereas effects of TMS session have a 1-week-long washout period (George, Lisanby, & Sackeim, 1999). It is an important goal to maintain and reward positive effects of individual TMS session during rTMS treatment course, which usually consists of 12 weekly sessions.

Methods

In this study we used a novel approach by combining prefrontal rTMS sessions with prefrontal NFB to prolong and reinforce TMS-induced electrophysiological changes using an operant conditioning paradigm. The pilot trial recruited children and adolescents with ASD. Outcome measures included behavioral and psychophysiological responses. In particular, both active treatment groups (TMS only, $N = 20$; NFB only, $N = 8$; TMS with neurofeedback, $N = 6$; waitlist, $N = 20$) were

assessed at (a) the initial baseline using clinical behavioral questionnaires, that is, ABC (Aman & Singh, 1994), SRS (Constantino & Gruber, 2005), RBS (Bodfish, Symons, & Lewis, 1999), and performed a visual oddball task with evoked EEG response recording (Kanizsa illusory figure test), and (b) postcompletion of 12 sessions of treatment (TMS, NFB, TMS+ NFB), or a 4- to 8-week-long waiting period.

Discussion and Results

The project links behavioral, clinical, and electrophysiological (EEG and ERP) responses during cognitive tests and TMS-neurofeedback treatment outcomes with an underlying developmental neuropathology model derived from investigations in our laboratory. The study represents a new development in combining rTMS with EEG biofeedback and using functional outcome measures (cognitive ERP, EEG, and autonomic nervous system activity measures during rTMS sessions), where an integrated TMS-neurofeedback trial represents a theory-guided psychiatric neurotherapy in autism. In this exploratory project we used active rTMS, waitlist, and neurofeedback training combinations to examine effects of each intervention arm and their combination (TMS, neurofeedback, TMS with neurofeedback, waitlist) on EEG, ERP, autonomic physiology (heart rate, HV variability, skin conductance level, skin temperature), and other functional and behavioral clinical outcomes in autism. Collected preliminary data support our concept that (a) rTMS induces decreased sympathetic arousal and anxiety and improves executive functioning as evidenced by normalization of EEG/ERP responses during executive function tests and clinical behavioral evaluations, and (b) the combination of TMS with EEG neurofeedback may result in a synergetic outcome. We compared several clinical, behavioral, cognitive, and emotional measures to select those more sensitive to predicted changes resulting from the combined neurotherapy.

Conclusion

The results of our innovative pilot study were used to design a research project to explore clinical efficacy of developed novel integrated TMS/biofeedback neuromodulatory intervention for treatment of core autism symptoms. The grant proposal based on these concepts and pilot data has been submitted to a federal agency as an exploratory project.

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POSTER

Assessment of Memory Deficit and Malingering with A ''Dual-Probe'' Protocol, Using Incidentally Learned Information and Pictorial Stimuli

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Introduction

Memory is one of the most vulnerable cognitive functions affected in cases of brain traumas, such as head injury, poisoning, radiation, viral infection, stroke, and so on. Expectation to obtain monetary compensation increases motivation of ''victims'' to exaggerate and feign memory deficit. As estimated, about half of all the cases presented with ''compromised memory'' are actually cases of malingered psychological symptoms. Concerns raised neuromodulatory by psychologists that the number of cases with feigned memory deficit continues growing led to increased interest in developing methods and techniques to identify malingerers. One of the major challenges faced by researchers and practitioners utilizing neuropsychological tests and behavioral techniques to assess memory deficit is poor reliability of the conclusions of whether or not the patient has sustained real memory deficit or is malingering amnesia.

> A major roadblock to the study of malingered amnesia is the marked constraint on the verifiability of memory complaints. Unless an individual eventually admits that he or she has been intentionally deceptive, the clinician can never establish with confidence whether he or she has been malingering. Individuals willing to step forward and acknowledge their deceitfulness are rarely, under any circumstances, available. As a result, malingerers usually cannot be identified independently of the outcome measures... being evaluated. (Brandt, 1988)

Recently developed ERP-based tests reveal a high level of resistance to the effects of malingering compared to neuropsychological/behavioral tests of memory (Rosenfeld, 2011). Last year we demonstrated effectiveness of the ''Dual-Probe'' ERP-based test to identify exaggeration of memory deficit (Labkovsky & Rosenfeld, 2011). The accuracy with the Dual-Probe protocol using personally relevant autobiographical information reached 100% (with either one or both probes). The present study demonstrates effectiveness of the Dual-Probe protocol utilizing incidentally learned information and pictorial stimuli with 8 irrelevant stimuli in each of the 2 parts of a trial.

Methods

In the Dual-Probe protocol, each trial consists of two parts. There are about 400 trials in one block. Each of the 2 parts has one ''Probe'' (familiar to the subject item) and a few ''Irrelevant'' stimuli (unknown to the subject). In each part, stimuli represent different domains. In the current study, the first part of a trial consisted of pictorial stimuli. There was one probe

(P1) and 8 irrelevants (I1.1–I1.8—all 8 irrelevants combined from Part 1 define Iall1). The probe was an image of the flash drive (which the subject was asked to steal and hide), and 8 irrelevants were pictures of items that were never shown to the subject before. In the second part of a trial, the stimuli were names. The probe (P2) was the name of the person whose mailbox the flash drive was taken from by the subject, and the 8 irrelevants were some random names (I2.1–I2.8, and Iall2 = combined irrelevants in Part 2). There also was a target stimulus (Target) in the second part of a trial that was a task-relevant name requiring a unique button press (with unique ''assigned significance,'' as in Johnson, 1986). In each trial, the subject first saw an image (P1) or one of the 8 pictorial irrelevants (I1.1–I1.8) followed by P2, or an ''Irrelevant'' from Part 2 (I2.1–I2.8) or a ''Target.'' Subjects randomly pressed 1 of 5 buttons on one response box when they saw a pictorial stimulus (1st part), and they pressed 1 of 2 buttons on another response box to a name (2nd part).

Results

For statistical analysis in the group with the Dual-Probe protocol using incidentally learned information and pictorial stimuli ($N = 11$), we implemented an analysis of variance (ANOVA) and t tests. The ANOVA (2 parts of a trial $\times$ 2 stimulus types) showed significant stimulus type effect, $F(1, 20) = 39.363$, $p < .001$. There was no significant group effect (between two parts of a trial), $F(1, 20) = 1.192$, $p = .29$, and no interaction (Pr vs. Iall $\times$ Trial Part). Follow-up t tests revealed significant differences in the first part of a trial between P1 and Iall1 amplitudes, $t(10) = 4.98$, $p < .001$, and in the second part of a trial, between P2 and Iall2, $t(10) = 3.83$, $p < .001$. Hit rate was 100% with either P1 (1 or 2) or P2 (1 or 2) detected as recognizing the probes even if claiming a feigned stimulus recognition deficit.

Conclusions

The Dual-Probe ERP-based protocol for assessment of memory deficit and malingering shows a high level of accuracy. When subjects try to feign cognitive impairment and, specifically deny recognition of familiar stimuli, the Dual-Probe (with pictorial stimuli) approach reflects the subject's ability to recognize familiar stimuli. Thus, the Dual-Probe protocol can be used in situations where subjects are unable, or unwilling, to report their recollection for incidentally acquired or learned information. Further research is required to investigate how introduction of countermeasures and changing number or irrelevants affect accuracy of the Dual-Probe protocol with pictorial stimuli and incidentally learned or rehearsed information.

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KEYNOTE PRESENTATION

Neurofeedback Training Induces Changes in Grey and White Matter

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We demonstrated some time ago that increasing Beta1 band through neurofeedback

training (NFT) can enhance activity in brain regions involved in various attentional processes (Beauregard & & Lévesque, 2006; Lévesque, Beauregard, & Mensour, 2006). One objective of this structural magnetic resonance imaging (MRI) study was to investigate whether a NFT protocol designed to improve attention might induce changes in grey matter volume (GMV) in areas known to be implicated in attention. Another objective was to explore whether such a NFT protocol might lead to alterations in white matter tracts involved in attention processing. Thirty university students ($M = 22.2$, $SD = 2.4$) with no history of neurological or psychiatric disorders were recruited. Participants were randomly assigned to an experimental group (EXP, NFT; $n = 12$, $M = 22.4$, $SD = 1.6$), a sham group (SHAM, to control for a possible placebo effect; $n = 12$, 9 $M = 22.0$, $SD = 3.1$), or a control group (CON, to control for the passage of time; $n = 6$, 3 $M = 20.7$, $SD = 1.0$). NFT was conducted over 13.5 weeks for a total of 40 sessions. Participants in the EXP group were trained to enhance the amplitude of their beta1 waves in the right hemisphere. Electrodes were placed at F4 and P4. MRI data were acquired 1 week before (Time 1) and 1 week after (Time 2) NFT. Regional changes in GMV were analyzed using voxel-based morphometry. As for white matter, a diffusion tensor model was fitted to diffusion tensor imaging data to produce whole brain maps of fractional anisotropy (FA) that were compared between the two time points using tract-based spatial statistics (Smith et al., 2006). The attentional skills of all participants were assessed at Time 1 and Time 2 using the Integrated Visual Auditory continuous performance test (IVA). In the EXP group, the scores on the IVA Full Scale Attention Quotient (which is based on measures of both visual and auditory attention) significantly increased at Time 2, compared to Time 1 ($p < .005$). Scores on auditory attention were also significantly higher ($p < .005$) following NFT. For participants in the SHAM group, scores on visual attention were greater ($p < .005$) at Time 2 relative to Time 1. No difference in attentional performance was noted at Time 2, compared to Time 1, for members of the CON group. In other respects, a significant ($p < .001$ uncorrected) grey matter volume increase was found in the EXP group, at Time 2 relative to Time 1, in a number of cortical areas located in the right hemisphere (RH; inferior, middle, and superior frontal gyri; inferior parietal lobule; inferior temporal gyrus) and left hemisphere (LH; inferior and superior frontal gyri; inferior and superior temporal gyri; superior parietal lobule). With regard to white matter, significant increases in FA were measured in the superior longitudinal fasciculus (LH, $p < .0001$), inferior longitudinal fasciculus (LH, $p < .005$), anterior limb of the internal capsule (LH, $p < .0005$), anterior corona radiata (RH, $p < .005$), cingulum (RH and LH, $p < .0001$), and corpus callosum (genu: $p < .005$; body: $p < .001$; splenium: $p < .0005$). No change in grey and white matter was noted for members of the SHAM and CON groups. These findings suggest that NFT can induce changes in brain regions implicated in attention. Our findings also indicate that NFT can produce modifications in white matter tracts involved in attentional processes.

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ORAL PRESENTATION

Self-Regulation of Slow Cortical Potentials in Patients with Intractable Epilepsy—Eight Years After

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Objective

The aim of this study was to answer the question whether the effects of a behavior therapy program for patients with intractable epilepsies that included self-regulation of slow cortical potentials (SCP) were still present more than 8 years after the end of treatment (Kotchoubey et al., 2001). In the main study, the experimental group (SCP group) received a training of SCP regulation, whereas the two control groups were treated either with respiratory feedback therapy (RES) or adjustment of antiepileptic medications (MED) in combination with psychosocial treatment.

Methods

Seizure frequency, medication, psychological variables and neuropsychological functions of the patients of one experimental (SCP-Feedback) and two control (Respiratory Feedback [RESP]/Adjustment of antiepileptic medication [MED]) groups were assessed and compared. From 41 patients in the experimental group, 19 patients were recruited along with 2 patients from each control group (out of 12 RESP and 11 MED). The same psychological tests (WAIS-R; WMS; BDI; MMPI-2; d2; Locus of Control) were applied as in the original study. In addition, 3 SCP training sessions were conducted. A comparison with the control groups was not feasible due to a lack of participants out of these groups.

Results

Since the end of treatment, a statistically significant decrease in the number of seizures was observed. With the exemption of those patients that underwent neurosurgery, participants were still able to self-regulate their SCPs during the feedback condition. IQ and memory values were worse compared to the 1-year follow-up but not below the level of pretreatment assessments. Psychological variables were still in a nonclinical, normal range.

Conclusions

About 8 years after the end of an EEG-biofeedback treatment for patients with refractory epilepsy, a statistically significant trend to a lasting reduction in seizure frequency was observed. All patients except those who had received surgical treatment in the meantime still had the ability to self-regulate their SCPs. Given such a long follow-up period, the possible impact of confounding variables has to be taken into account. In addition, considering the small number of patients participating in this follow-up evaluation and the fact that members of the control groups refused to take part, causal conclusions cannot be drawn. Yet, given the positive and sustained development of the patients who participated in the EEG biofeedback training, future treatment planning and research should not only aim to optimize conventional therapies but should include EEG biofeedback as an option in the treatment of patients with (intractable) epilepsies.

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