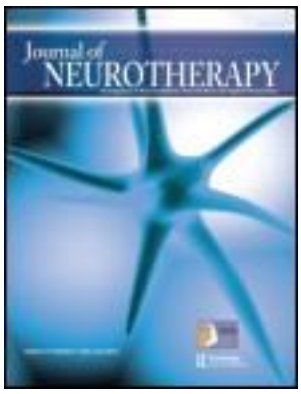

Journal of Neurotherapy: Investigations in Neuromodulation, Neurofeedback and Applied Neuroscience

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PROCEEDINGS OF THE 2011 ISNR CONFERENCE

SELECTED ABSTRACTS OF CONFERENCE PRESENTATIONS AT THE 2011 INTERNATIONAL SOCIETY FOR NEUROFEEDBACK AND RESEARCH (ISNR) 19TH ISNR CONFERENCE, PHOENIX, ARIZONA

Panel: Dimensions of Experience and First-Person Science

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This presentation proposes a long-range program of research on the relationship of human subjective experience to its physiological and environmental concomitants. Subjective experience has been a long-debated topic, and attempts to rule it out of bounds of scientific inquiry have not been totally successful. The history of modern psychology started in the late 19th century as the study of consciousness, with trained introspection as the method of observation and the verbal reports of the results being the data. Among the reasons for the failure of the approach was disagreement among different observers in the verbal reports of their introspections, presumably of the same object of observation. However, the process of introspection itself, apart from the reporting thereof, is the observing of events internal to the observer. Dreams, imagery, pains, hopes, thoughts, and feelings are still present, for all their privacy, waiting to be comprehended more adequately in a framework of all scientific knowledge. Because the activity being observed is private to the observer, we refer to this as first-person observation, and when reported verbally is commonly termed subjective report and is sometimes nonfalsifiable. This contrasts with the third-person reporting of observation of events external to the observer, where the reports of the observations can be publicly verified. Such reports are called objective, sometimes falsifiable.

Stoyva and I (1968, *Psychological Review, 75*, 192–205) pointed out that the temporal correlates of such private events with publicly observable events (both physiological processes of the observer himself as well as events of his external environment) are an important tool for consciousness studies. The logic is that when there is covariation over time between the occurrence of a private event (such as dreaming, as indicated by verbal report upon being awakened) and the presence of eye movements and EEG stage changes prior to the awakening, the convergence of the two observables provides increased confidence that dreaming did occur as suggested by the report.

That physiological events can thus be at least partial indicators of subjective experience underlies several avenues of research. One, exemplified by the current work of Richard Davidson and associates, shows that the magnetic resonance images of the brains of meditators are related to their activity of meditation. Thus the ancient human activity of deploying attention in specific ways as reported by the meditators is at least partially indexed by a physiological marker, thus making possible studies of the specific brain processes underlying the first-person experiences of these subjects. Another approach is one I reported on in 1962 and 1968 to train subjects by operant discrimination procedures to identify moments, each time I rang a single ding of a bell, when occipital EEG alpha activity was dominant, versus moments when it was absent, by a simple dichotomous verbal response (''A'' for

alpha dominance, ''B'' for its absence). Successful discrimination was achieved by most subjects, permitting inquiry of the subjects as to the subjective differences between the two EEG states. Despite considerable individual differences in some of the verbal reports, there was a tendency toward common verbal characterizations of the differences, suggesting that the subjective experiences themselves of most persons may have common correlates in brain activity.

To reduce the noise found in everyday language reports of subjective experience, it is proposed first that extensive discrimination training and feedback training be used on a selected variety of physiological measures, so as to increase the sensitivity of the individual to the ''feel'' of discriminating and/or controlling each of, say, 20 measures. Then, from each subject are obtained paired comparison ratings of the degree of subjective similarity (on a 5-point scale, say) of each measure to every other measure. This will result in a matrix to which principal components analysis can be done to specify the independent dimensions of the total subjective space associated with the measures. Thus, for example, the ''feel'' of EEG alpha at the central leads might be specified as occupying a specific spot in the derived multidimensional space. Verbal labels can be applied to the dimensions later, with the risk of introducing cultural biases in word usage. However, to the extent that the maps derived from all subjects are similar to each other, there will be a basis for improved verbal agreements about the subjective qualities.

The method would significantly increase the precision of mapping the subjective judgments of physiological measures. Of course, the representativeness to real life of the measures selected for training will be crucial, and this will emerge only after very extensive multimeasure research in basic psychophysiology of everyday life, particularly that involving interpersonal interactions.

PowerPoint slides will be used to illustrate the power of dimensional analysis of a matrix of subjective ratings of paired comparisons. As an example, a map will be shown of different food tastes, dimensionalized along sweet, sour, bitter, and salty (which rather well account for all food tastes). It would show where, for example, where apples, sweet pickles, raw cucumbers, and beef would likely appear as projections along the axes of the multidimensional space.

Validation of a Global Live Z-Score Protocol in a Randomized, Sham-Controlled Study of Cognitive Decline in Aging

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The objective of this report is to present and interpret objective data that validate a global live z-score training (LZT) neurofeedback protocol. We present data for 3 levels of validation of a global live z-score protocol used for operant training. These are single-subject within-session ($N = 1$); single-subject across-sessions ($N = 3$); and a blind, multiple-subject randomized sham-controlled study (RCT; $N = 79$). The validation consists of (a) specific within-session z-score changes (40 min), (b) specific across-session z-score changes (10 sessions each), and specific enhancement of cognitive processing (8 sessions each). The RCT outcomes were measured by a battery of neuropsychological tests in the controlled study. The sham feedback consisted of ''yoked'' recorded EEG derived from a matched subject, who was undergoing similar neurofeedback training (NFT). The results confirm the proposed mechanism of action, which is operant learning (self-regulation) of a complex set of QEEG-derived parameters, in a conventional operant learning biofeedback paradigm. Both healthy elderly and mild Alzheimer's patients were included, and both were present in the experimental and the control groups. The measures that improved with real NFT were different

across the groups. The most compelling data were from a visual search task with the healthy elderly real NFT group. They showed enhanced selective attention across two different sensory binding conditions in an integrated visual-motor task. Real NFT improved attentional disengagement and alerting measures in the mild AD NFT group. Mock NFT either had no effect or elicited generalized slowing for both groups.

Results confirmed that the global LZT protocol leads to the expected specific EEG changes and that EEG changes were associated with expected cognitive improvement over time. Cognitive improvements were not seen in the sham-treated subjects in the RCT. These results verify that the mechanisms of LZT training operate as described and that they can produce measurable benefits in improved brain activation and connectivity, and associated cognitive function. Clinical application, including relationships to observed phenotypes, will be described. These results provide a basis for clinical application, continued studies, and further development of protocol designs. Possible weaknesses in the study will be described, including the sham feedback, possible repeated-measures effects, and the need for analysis of additional behavioral measures that were taken, including methods proposed for refining these results.

Financial Interest

Dr. Collura has a financial interest in BrainMaster Technologies, Inc.

Neurofeedback for Adult Attention-Deficit/Hyperactivity Disorder: Preliminary Findings of Slow Cortical Potential Feedback

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Introduction

Attention deficit hyperactivity disorder (ADHD) is characterized by symptoms of inattention, impulsivity, and hyperactivity, which persist into adulthood for 4 to 5% of patients (Goodman & Thase, 2009). Hitherto, only a few EEG studies have investigated ADHD in an adult population (Bresnahan, Anderson, & Barry, 1999; Bresnahan & Barry, 2002; Clarke et al., 2008a, 2008b, Hale et al., 2009; Koehler et al., 2009; Loo et al., 2009; Thompson & Thompson, 2005; White, 2001, 2003), and to our knowledge no studies have assessed the efficacy of neurofeedback training on symptom reduction. Neurofeedback training has been applied effectively in various areas, especially in the treatment of childhood ADHD (Arns, de Ridder, Strehl, Breteler, & Coenen, 2009). This study is designed to investigate the effect of slow cortical potentials (SCP) neurofeedback training on symptomatology and neurophysiological parameters in an adult ADHD population following 30 training sessions and after a 6-month follow-up period.

Methods

Continuous 19-channel EEG was acquired from 10 adult participants who met *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; American Psychiatric Association, 1994) criteria for ADHD (combined, inattentive, or hyperactive type), without additional serious physical, neurological, or psychiatric disorders, and a full-scale IQ greater than 80. EEG recordings were collected at pre/mid/post-follow-up treatment intervals and included EO, EC, P300, and CNV tasks, as well as ADHD behavioral questionnaires. Participants underwent 30 sessions of SCP neurofeedback training at CZ, referenced to A1, ground A2, with vertical and horizontal ocular correction (Strehl, Leins, Goth, Klinger, & Birbaumer, 2006).

Results

This investigation is in progress. The changes in behavioral and neurophysiologic parameters following 15 sessions of SCP feedback will be presented at the time of the conference.

Conclusion

SCP neurofeedback therapy has not previously been investigated in an adult population and may yield valuable findings related to alternative treatments for adult ADHD. Treatment

implications, study limitations, and future directions in research will be addressed.

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STUDENT PRESENTATION

Pilot Data Investigating the EEG Sources of Personality and Attachment

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Introduction

In recent years there has been a surge of data investigating the neural assemblies implicated in attachment and personality, specifically the Big Five (Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness). The current study presents pilot data investigating the EEG current source density (CSD) associated with the Experiences in Close Relationships Scale and the 34-item Transition to College Inventory (TTC).

Methods

We collected data from 16 nonclinical undergraduate students (8 male) while EEG was

continuously recorded during the completion of each of the assessment measures. Response items were marked within the EEG record. The segments prior to the response were extrapolated and compared to eyes-opened baseline, as well as to each other.

Results

Data indicate the maximal increases in CSD for the Emotional Closeness in Relationships (ECR) as compared to baseline occur in BA 21 at right middle temporal gyrus, BA 44 at left inferior frontal gyrus, BA 13 at left insular cortex, BA 18 at left cuneus, and BA 7 left parietal lobe/precuneus. TTC compared to baseline shows maximal increases in CSD in right BA 21 middle temporal gyrus, BA 31 left posterior cingulate, left BA 18/19 cuneus, and left BA 7 precuneus. ECR compared to TTC showed maximal increased CSD in BA 32 medial and right anterior cingulate, BA 10 left middle frontal gyrus, left BA 4 precentral gyrus, and BA 20 right fusiform gyrus.

Conclusions

The data obtained in this early study are very similar to studies that have employed functional magnetic resonance imaging to measure personality and other attachment measures. The ECR and TTC show similarities as contrasted with eyed-opened baseline and significant differences between the two measures. The regions shown increased in CSD include regions known to be associated with self-relevant information processing as well as self-regulation and social and language processes. Future research aims are to increase sample size to investigate both of these measures in more depth. Potential network properties and implications for neurofeedback paradigms will be discussed.

INVITED PRESENTATION

EEG Abnormalities in Children with Attention-Deficit/Hyperactivity Disorder: Linking Brain and Behaviour

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Attention-Deficit/Hyperactivity Disorder (AD/HD) is one of the most common psychiatric disorders of childhood, affecting approximately 5% of primary school children. Almost all models of the disorder accept that the behavioral cluster that is AD/HD results from an underlying central nervous system (CNS) dysfunction. However, the exact nature of this dysfunction is poorly understood. Several electrophysiological-based models of AD/HD have been proposed, and recent research has suggested that most are too simplistic in nature and the underlying CNS dysfunctions are inaccurately labeled. Part of the problem results from the use of multiple bands in the analysis of the EEG, as this approach does not allow an understanding of the role of any discrete band on functioning. In a different approach, our group has been decomposing the EEG into single bands and relating anomalies in these bands to specific brain states (such as arousal) and to behavior. Results from a number of studies, and their implications for understanding the link between brain and behavior, will be discussed.

Reliability of Quantitative EEG: Power, Phase, Coherence, and LORETA Current Source Density

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Introduction

In recent years the use of quantitative electroencephalography (qEEG) and LORETA methods in clinical and research settings has increased. It has been poorly demonstrated that qEEG or computerized analyses of the EEG is less than reliable across time, despite numerous studies demonstrating the opposite. The current study sought to determine the reliability of qEEG, connectivity measures, and LORETA current source density measured across a span of 30 days. We hypothesized that all measures collected would show significant reliability across time.

Methods

We recorded 4-min eyes-closed baseline (ECB) and eyed-opened baseline (EOB) recordings at 2 intervals 30 days apart. We analyzed the EEG data using NeuroGuide, version 6.3. We calculated peak frequency, phase, and coherence as well as LORETA z-scored current source density as compared to the Lifespan database. We entered the data into reliability analyses, using SPSS 17 with a two-way mixed model with an absolute agreement definition. We compared all frequency bands at randomly selected electrode sites.

Early Results

The reliability analyses for peak frequency (alpha 8–12 Hz) shows a Cronbach's alpha of .71 for the ECB in select sites, whereas the EOB shows an alpha of .95 at the same sites. The Coherence analyses show a Cronbach's alpha of .79 at select sites for ECB and .99 for the same sites in EOB. Phase shows an alpha of .88 for ECB and .93 for EOB. LORETA current source density from select region of interest shows similar effects with ECB showing .88 and EOB showing .92.

Discussion

The current data analysis is in progress; however, early results suggest that even in small samples the qEEG and LORETA data are reliable measures across time. The results of this study are further evidence supporting the use of computerized EEG and LORETA in both the clinical and research setting.

STUDENT PRESENTATION

Long-Term Effectiveness of Neurofeedback Combined with Metacognitive Training for Children with ADHD: A Pilot Study

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Introduction

Neurofeedback is an alternative treatment to alleviate the primary symptoms of Attention Deficit Hyperactivity Disorder (ADHD), including inattention, hyperactivity, and impulsivity. Several studies have shown that neurofeedback training is effective in improving behavioral functioning, but more research is still needed to help us understand how the neurofeedback training benefits students with ADHD, especially in Canadian populations. Typically, most ADHD interventions focus on managing the behaviors in students with ADHD and neglecting the intervention in optimizing the academic performance of these students. In this study, the intervention incorporated metacognitive training as a part of the neurofeedback training to address both academic and behavioral difficulties. This paper covers part of a pilot study. In this paper, a secondary data analysis approach is used to evaluate the short-term impact of a 40-session neurofeedback training program combined with metacognitive strategies training. The goal of this paper is to determine whether the number of ADHD traits rated by caregivers changed from pretraining to posttraining.

Methods

In this secondary data analysis, the existing questionnaire and computerized assessment data from the ADD Centre (Mississauga), at the pretreatment and the immediate posttreatment points was collected. The sample size was 318, and the inclusion criteria were (a) a diagnosis of ADHD/ADD, and (b) 6 to 17 years of age at the time of training, completion of 40 sessions of 1-hr neurofeedback training combined with metacognitive strategies training (typically twice a week). The training program focuses on decreasing the theta wave activity (typically 3–7 Hz) and increasing the sensorimotor rhythm (typically 13–15 Hz). Metacognitive training was taught for 5 to 10 min during the session to learn strategies related to academic tasks. The questionnaire data, collected for all participants, were completed by caregivers and included the (a) Conner's Global Index–Parent Version, (b) *Diagnostic and Statistical Manual of Mental Disorders* symptom list, and (c) ADD-Q. For a subset of 110 participants, computerized assessment data was also collected: Test of Variables of Attention and IVA + Plus – Visual & Auditory Attention

Testing. These computerized assessment data were then later correlated with the questionnaire data to determine the reliability of the questionnaire results.

Results

In this study, significant behavior improvements in both hyperactive traits, $F(4, 132) = 969.200$, $p < .0001$, and inattentive traits, $F(3, 123) = 389.440$, $p < .0001$, were reported on the 3 questionnaires and 2 computerized assessments from pre- and post 40 sessions of training. Furthermore, there are 5 control variables in this study: gender, age at the time of training, IQ at the time of training, medication used at the time of training, and ADHD subtypes. No significant difference between gender (male, $n = 252$, and female, $n = 66$), age at the time of training (age 6–12, $n = 212$, and age 13–17, $n = 67$), IQ at the time of training (below average, $n = 20$; average, $n = 97$; above average, $n = 42$), medication intake at the time of training (have medication, $n = 69$, and no medication, $n = 209$), and ADHD subtypes (ADHD Combined Type, $n = 95$; ADHD Inattentive Type, $n = 96$; ADD, $n = 19$; ADHD without a labeled subtype, $n = 69$) were found.

Conclusions

The results of this study provide evidence supporting the use of neurofeedback combined with metacognitive training as an effective intervention for ADHD.

A Look at Your Brain on Joy

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Introduction

Why should we take a look at the brain on joy? Besides being a part of what makes life worth living, positive emotions such as joy have been shown to have health benefits. Resisting the common cold and flu are linked to the tendency to experience positive emotion (Cohen, Alper, Doyle, Treanor, & Turner, 2006). Positive emotional style is associated with lower rates of stroke and better coronary recovery. The lack of joy was found to be one of the most important symptoms linked with risk of depression after age 60 (Hein et al., 2003).

Methods

After providing informed consent, a nonclinical sample of 25 university students underwent continuous EEG recording while they envisioned a personal experience that brought them maximal joy. After baseline and task EEG recording, participants also supplied open-ended reports of their experiences during recording, as well as completion of a health symptoms inventory and optimism/pessimism scale. EEG source localization using sLORETA was performed and comparison of the self in experience of joy condition to baseline was made using all voxel-by-voxel tests. Voxels of significant difference were mapped onto a Montreal Neurological Institute atlas containing 6,329 five mm voxels.

Results

Differences between task and eyes-open baselines will be discussed with regard to regions of interest.

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A Study Comparing the Brain Function of Healthy and ADHD Adults During Rest and Stroop Task in EEG/ERP and fMRI

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Introduction

The prevalence of Attention Deficit Hyperactivity Disorder (ADHD) is an estimated 4.1% in adults, second only to depression. Recently, several quantitative electroencephalographic, event-related potential (ERP), and functional magnetic resonance imaging (fMRI) studies have been completed to examine electrophysiological and blood flow behaviors in adults with ADHD. This EEG/ERP/fMRI study correlated brain behavior from each neuroimaging method and elucidated functional connectivity patterns in the ADHD group during resting state (eyes open and eyes closed) and an active cognitive task (Stroop). We examined the default mode network (DMN) to ascertain the differences during rest and the Stroop task. The DMN consists of 12 functionally related regions that are consistently shown increased in activity in an eyes-closed resting condition as compared to functionally specific cognitive tasks or eyes-opened resting condition. Given the regional deficits shown in ADHD research, we examined them and their specific relationship with the bilateral anterior insular cortices. Numerous regions within the default network, especially left medial prefrontal and anterior medial regions are shown (assuming sources at or near the surface electrodes F3, Fz, and F7 contribute to the ERP average) to contribute many of the putative mechanisms found in ERP research (e.g., frontal NoGo-N2 and P3, Error-related Negativity, etc.).

Methods

Seven controls (4 F, 3 M) and 6 ADHD (3 F, 3 M) adults (M age = 42.9) came to Applied fMRI Institute to complete a fMRI FanTab neuropsychological test battery, eyes open, eyes closed EEG, and Stroop task for ERPs. They were age- and sex-matched as closely as possible and were counterbalanced for EEG/fMRI recordings.

Results

The fMRI data indicate resting state networks are less active in ADHD than controls—with the largest effect shown in the right insula (which has also been shown to exact some control over activity in the DMN). These fMRI data identify numerous regions with decrements in activity in task versus resting condition, including the anterior cingulate, left BA 40 and regions in prefrontal cortex. EEG current source density indicate the ADHD subjects show deficits in delta and theta in the DMN during rest and less activity overall as contrasted to controls. Specific regions within the default network show deficits in ADHD as compared to controls, specifically in the delta, alpha, and beta frequencies in left BA 10/47, 32, and 8.

Conclusion

The effects shown in the data suggest that regions associated with salience, attention, and self-regulatory processes are dysfunctional in the ADHD population. At the core of these network deficits are the bilateral insular cortices, the AC and regions known to be associated with affect regulation, monitoring the physical state of the body (e.g., insula and inferior frontal cortex–BA 10/47). These data show that left BA 40 is a very important area for attentional maintenance and integrative processes. In addition, it has been shown that the visual N100 (frontal sites) and P300 (parietal sites) ERPs are attenuated in ADHD children, which may be an indication of a deficit in selective attention. Our ERP data are still under review.

Recruitment of neural resources involving temporal correlations provides important information about both attentional and self-regulatory processes in ADHD individuals as compared to healthy controls. These data provide important information relating to potential biomarkers for ADHD and increase the specificity of methods for neurotherapy treatment of ADHD. The data also confirm that EEG is an adequate methodology to evaluate ADHD.

STUDENT PRESENTATION

LORETA Neurofeedback and the Morphology of Working Memory and Processing Speed

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Introduction

Operant conditioning of the electroencephalogram (EEG) offers the potential to improve attentional and cognitive processing in psychological syndromes but also has the exciting potential for improving these functions in normal populations. In recent years, there is increasing interest in basic mechanisms of self-regulation and the associated neuronal distributions. Moreover, there is an exciting trend toward uncovering the morphology of psychological constructs. This study sought to describe the morphological neural substrates of working memory and processing speed as influenced by LORETA neurofeedback (LNFB) in the anterior cingulate and bilateral prefrontal cortices.

Methods

We examine the neural correlates of self-regulation in both normal populations of 16 undergraduate students, each underwent between 20 and 30 sessions of LNFB training in 1 of 6 regions of interest: dorsal anterior cingulate, bilateral prefrontal cortex, and precuneus. The sessions consisted of 3-min pre- and postbaselines and 4-min to 5-min training rounds. We measured efficacy of LNFB with pre- and postworking memory (WMI) and processing speed index (PSI) scores of the Wechsler Adult Intelligence Scale—Third Edition.

Results

The participants were able to produce significant learning curves and increase levels of current source density at the specified region of training. The regions of training exhibit differential effects upon other regions of the cortex as determined by LORETA when trained exclusively. There are also significant comodulation effects within the region of training as well as between regions when examining the correlational structure of the EEG current source density. The training influenced increases in WMI and PSI scores.

Conclusions

Operant conditioning of the EEG in spatial specific intracranial regions of interest increases the likelihood of improving our functional knowledge of self-regulatory and cognitive mechanisms in the human brain. The correlative structure between the subtest scores of the WMI and PSI appears to influence specific Frequency × Region associations. The data presented offer an exciting direction for understanding the basic mechanisms of self-regulation and its cognitive correlates.

INVITED PRESENTATION

EEG, fMRI, and tDCS/tACS Applications for Disorders of Consciousness and Movement Disorders

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Part 1: Assessment of Consciousness in Nonresponsive Patients: fMRI and EEG data

Is there a way to assess consciousness in apparently nonresponsive patients? This presentation attempts to address this question by measuring hemodynamic and electrical brain activity from patients with persistent vegetative state (PVS) or minimally conscious state (MCS). fMRI, EEG, and PET data will be presented, recorded from patients with PVS or MCS, and from healthy controls. Significant findings and methodological drawbacks for each technique will be discussed.

Part 2: tDCS and tACS in Patients with Dystonia and with PVS/MCS

A recently expanding application for the treatment of brain disorders is transcranial electrical

stimulation. This noninvasive method has been shown to affect motor and cognitive functions in healthy volunteers and in neurological patients, as well as to reduce symptoms in a number of brain disorders. This presentation will illustrate the potential of transcranial direct current stimulation (tDCS) and of transcranial alternate current stimulation (tACS) through two paradigms: idiopathic intractable dystonia and PVS/MCS. The former is a movement disorder with no other neurological or cognitive deficits, and with absent radiological findings. The later is a totally incapacitating condition with moderate to severe brain lesions of atrophy.

KEYNOTE PRESENTATION

The Human Brain Resting State Networks Based on High Time Resolution EEG: Comparison to Metabolism-Based Networks

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Intrinsic resting activity is not simply the ground state of an inactive brain. Rather, it constitutes the dynamic substrate of the ''present,'' momentary state of the brain and determines the fate of incoming information (Lehmann, 1990).

Early intrinsic activity studies were due to Hans Berger (1929) with the first human EEG measurements. The introduction of multichannel EEG, with emphasis on scalp imaging (topographic mapping) of the brain electric activity, advanced the field significantly, with the development of the microstate model (Lehmann, Ozaki, & Pal, 1987) and the normative databases of brain rhythm properties (John et al., 1977).

Renewed interest in the resting state comes from the field of brain imaging techniques such as functional magnetic resonance imaging (fMRI) and positron emission tomography. A large number of resting state studies converge in producing brain networks that allegedly have functional significance such as attention, executive control, salience, and the default mode, to name but a few. These results are based on an independent components analysis (ICA) of extremely slow time series of metabolic activity.

In this study we analyze electric brain activity at very high time resolution, based on resting, awake, and eyes-closed EEG recordings from 6 different groups of subjects across 5 different labs. Scalp electric potential differences were used to compute electric neuronal activity on the cortex using standardized low resolution electromagnetic tomography (sLORETA; Pascual-Marqui, 2002). Each group of subjects was analyzed separately, using the most common ICA methodology as in recent fMRI literature (Allen et al., 2011; Pascual-Marqui & Biscay-Lirio, 2011). Validation of the electric resting state networks was assessed by the reproducibility across different groups, which was remarkably high. Results show that many of the electric networks consist of fewer core brain areas (e.g., the left and right temporal regions appear in two distinct electric networks) while they typically appear in one single metabolic network. This difference might be due to the slow temporal nature of metabolic changes, which lumps together over time what is actually taking place independently when seen at higher time resolution with electric activity tomography. Another unique interesting difference to metabolic networks is the appearance of electric networks that consist of pairs of brain regions working against each other (i.e., activation in one region is linked to deactivation of the other). These methods and results may help in understanding normal and pathological brain function from a high time resolution network perspective.

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Behavioral and EEG Effects of Lateralized EEG Biofeedback on Lateralized Attention Network Task and Lateralized Continuous Performance Task

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Introduction

We conducted a randomized, double-blind, placebo-controlled study of a short course of EEG Biofeedback to identify concurrent changes in behavioral and physiological correlates of hemispheric attention under EEG Biofeedback. Physiological changes throughout the biofeedback process were also measured with dense array EEG. Lateralized behavioral measures were created and examined in the context of lateralized EEG measures.

Methods

Participants received 1 of 4 biofeedback protocols (C3–A1 SMR, C4–A2 SMR, C3–A1 Beta, or Sham biofeedback) in 5 half-hour training sessions in 5 consecutive days. Veridical feedback was provided by a brief tone and a visual reward (a progressive image display). Sixty-four-channel EEG was recorded during biofeedback training and during 2 lateralized tests of hemispheric attention (Lateralized Attention Network Test [LANT] and Lateralized Continuous Performance Test [LCPT]). The LANT measures covert orienting of spatial attention and distinguishes between a measure of Orienting Benefit due to a valid spatial cue and a measure of Orienting Cost due to a spatially invalid cue. The LCPT contains lateralized CPT and Go-No/Go components. The LANT and LCPT were administered before biofeedback training and after 3 and 5 consecutive training sessions over 5 days of biofeedback.

Results

Behavioral. The biofeedback training protocols produced different behavioral effects on attention in the two hemispheres. Accuracy to targets proceeded by invalid cues yielded a significant interaction: Protocol (Sham, C3 SMR, C4 SMR, C3 Beta) × Session (1, 3, 5) × Visual Field (LVF, RVF); $p < .025$. Similarly there was a near-significant interaction: Protocol × Session × Cue (Valid, Neutral, Invalid); $p < .07$. These near-significant results become significant when we restrict our analysis to comparing specific protocol groups (e.g., Orienting Benefit of Sham v. C4 SMR; $p < .024$). Orienting performance to targets using valid and invalid spatial cues showed dissociation in visual fields across groups.

Physiological. Reward signals evoked by the training stimulus were characterized by a P50, an N100, both early and late P300 ERP components, and an N400. Training had a selective effect measured at trained scalp region, shown in event-related potential (ERP) and event-related slow potential (ERSP) components, including specific peak and latency changes to the first reward event in a series, in P300 Amplitude (Electrode × Group; $p < .039$), N400 Latency (Session × Electrode × Group; $p < .073$), and N400 Peak Amplitude (Session × Electrode; $p < .005$). The second reward events in a series also often exhibited near significant results (second

N100 amplitude at Session × Electrode × Group; $p < .07$, second P300 peak latency at Electrode × Group; $p < .022$).

Pairwise comparisons of protocol groups showed that behavioral and physiological responses also diverged by laterality of training and by veridical versus sham biofeedback.

Conclusion

We introduced a paired battery of lateralized attention tests and showed that measures of transient (LANT) and continuous (LCPT) attention networks are selectively affected by different EEG biofeedback protocols. In particular, lateralized attention (a) can be characterized both behaviorally and electrophysiologically, and (b) responds selectively to different biofeedback protocols. In addition, ERP components evoked by the biofeedback reward signal discriminated biofeedback effects within and across training sessions and protocols. These measures are therefore likely to reflect a monitor engaged by the biofeedback process.

The Usefulness of QEEG and ERPs in Predicting Treatment Outcome in ADHD and Depression

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The application of repetitive transcranial magnetic stimulation (rTMS) in major depressive disorder has been investigated intensively over the last years with several meta-analyses demonstrating that compared to placebo fast rTMS (>5 Hz) to the left dorsolateral prefrontal cortex (DLPFC; Schutter, 2009) and slow rTMS (>1 Hz) over the right DLPFC (Schutter, 2010) both exert mood enhancing effects. Similarly another neuromodulation technique, the application of neurofeedback in the treatment of attention deficit hyperactivity disorder (ADHD), has also been well investigated, and a recent meta-analysis concluded that neurofeedback has demonstrated a large effect size (ES) on impulsivity and inattention in the treatment of ADHD (Arns, de Ridder, Strehl, Breteler, & Coenen, 2009). This presentation will focus on how these treatments can be improved in clinical practice using quantitative electroencephalography (QEEG) and event-related potential (ERP) data, and to what degree treatment outcome can be predicted.

Depression Study

Ninety patients with a primary diagnosis of depression or dysthymia were included in this study. All subjects underwent neurophysiological testing before treatment (eyes-open and eyes-closed EEG, oddball ERP) and in addition several rating scales were assessed. The Beck Depression Inventory (BDI) was used to assess response to treatment. Thirty-three patients received slow rTMS over the right DLPFC (1 Hz) and 57 patients received fast rTMS over the left DLPFC (10 Hz). On average there was a 77.2% decrease in depressive symptoms after an average 20.56 sessions (BDI). There was no significant difference for response rates between fast rTMS (76.8%) and slow rTMS (81.8%).

Based on the literature, several EEG and ERP predictors of treatment response in major depressive disorder were investigated, and preliminary analysis demonstrates that nonresponders were characterized by (a) a slow frontal alpha peak frequency ($p = .010$) in agreement with Arns, Spronk, and Fitzgerald (2010); (b) parietal excess Delta ($p = .015$) in agreement with Knott (2000) and Knott, Telner, Lapierre, Browne, and Horn (1996); and (c) an increased P300 amplitude ($p = .031$), which was opposite to Bruder et al. (2001) but may suggest a subgroup characterized by increased anxiety complaints (Bruder et al., 2002).

ADHD Study

Twenty-one patients with a primary diagnosis of ADHD were included in this study. Diagnosis was confirmed using the Mini International Neuropsychiatric Interview. At intake, every 10th session and outtake an ADHD rating scale and a BDI were assessed to monitor treatment progress. For nonresponders and dropouts, a last-observation carried forward procedure

was used. One to 2 protocols were selected from 5 standard protocols and were personalized based on the individual QEEG.

At outtake 76% patients could be considered a responder (>50% decrease on one or more subscales of the ADHD rating scales), 14% a nonresponder, and 10% a dropout. The ES on inattention was 1.78 and for Impulsivity/Hyperactivity was 1.22.

The presented results are similar to the results from Monastra, Monastra, and George (2002) and substantially larger than the ES obtained in the meta-analysis. These results show promise for personalizing well-established neurofeedback protocols (such as central SMR/Theta and Fronto-central theta/beta) based on the individual EEG. Furthermore, a slow-alpha peak frequency (APF) had no relation to treatment outcome on ADHD specific scales but did demonstrate a clear relationship to comorbid depression symptoms, with subjects with a slow frontal APF responding less well. These results require further replication employing larger sample sizes, randomization, and adequate control groups.

Discussion

The results from these studies (along with pre- and post-QEEG results) and other studies from the literature will be integrated and recommendations will be made on what the implications of the presented biomarkers could be for current treatments and current practice but also specifically for designing new treatments.

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STUDENT PRESENTATION

Modulatory Effects of Ambient Prism Lenses on Spatial Attention in Autism: An Event-Related Potential Study

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Introduction

Autism is a developmental disorder marked by deficits in social interaction, communication, and behavior. One of the less studied deficits in autism is the dysfunction of the ambient visual system, which can affect attention, movement, and visual motor coordination (Kaplan, Edelson, & Seip, 1998). Focal vision, which involves the central visual field, is the visual system that traditional ophthalmologists address with eyeglasses. Ambient vision, which involves the entire visual field, is more dynamic and largely nonconscious and integrates with other sensory systems (Kaplan, 2006). Most autistic children have a preference for focal vision, which is why many display a fascination for numbers, letters, and objects. Their lack of attention to ambient vision limits their ability to process information regarding their gait, posture, movement, speech, and so on. The current study investigates the efficacy of ambient prism lenses used to correct deficits in ambient vision present in autism. In addition, this study aims to understand the abnormal neural and functional mechanisms underlying visual distortion in autism by incorporating neurophysiologic studies, behavioral studies, and event-related potential (ERP) measurements of spatial attention.

Methods

Potential participants were recruited from a pool of individuals with autism spectrum disorder with the assistance of FEAT (Families for Effective Autism Treatment, Louisville Chapter), Home of Innocents, and Weisskopf Child Evaluation Center (Louisville, KY). Prescreening questionnaires were filled out by parents, whereas the evaluation of visual abnormalities related to ambient vision deficits was conducted by Dr. Kaplan. Twenty subjects with autism were screened, and ambient correcting lenses were selected to match their visual deficits. Of the 20 individuals, 12 were able to comply with dense-array EEG recording required for ERP analysis. Mean age of subjects was 13.9 ± 3.0 years. The spatial attention task, programmed in E-Prime (Psychology Software Tools, PA), was represented a modification of a cued Posner spatial attention task (Posner, Edelson, & Seip, 1982). The experimental procedure consisted of 2 tasks and 4 total blocks, lasting total of 20 min. In Task A, the subjects were instructed to focus on the fixation cue in the center of the screen, then were given a cue (red square) in either the left or right visual field, followed by a target (a black X) in place of either left or right cue. In Task B, the procedure was the same, except the cues and targets appeared diagonally, in either top left and bottom right corners, or top right and bottom left corners. Probability of correctly cued targets was 80% in both blocks. Each subject completed each block with ambient lenses and placebo lenses. The order or prism and placebo lenses was counterbalanced. The ERP of interest included early (N100) and late (P300) components at the centro-parietal, and parieto-occipital topographic areas reflecting spatial attention processes (Di Russo, Martinez, & Hillyard, 2003; Gomez-Gonzalez, Clark, Luck, & Hillyard, 1994; Polich & Herbst, 2000). The analysis included comparison of behavioral performance (reaction time, accuracy) and ERP measures during blocks with and without ambient prism lenses.

Results and Discussion

Reaction time in prism lenses condition tended to be faster than in placebo lenses condition (356.1 ms vs. 382.2 ms, *ns*). Accuracy of responses in lenses versus placebo condition also showed trend to lower percentage of errors (5.6% vs. 14.2%) but did not reach significance level. Amplitude of the parieto-occipital N100 in horizontal congruent trial significantly higher ($-3.92\,\mu V$ vs. $-1.37\,\mu V$), $F(1,\ 23) = 7.79$, $p = .012$, during

prism lenses condition. Similar effect was significant for incongruent (invalid cue) trials (0.21 μV in placebo vs. −3.33 μV in lenses condition), $F(1, 23) = 6.40$, $p = .021$. Amplitude of the centro-parietal P300 (P3b) during more difficult diagonal incongruent condition was higher (4.65 μV vs. 2.05 μV), $F(1, 23) = 4.57$, $p = .045$, in ambient prism lenses condition, whereas latency P3b shorter (349.1 ms vs. 380.1 ms), $F(1, 23) = 7.72$, $p = .012$. These ERP effects of wearing ambient prism lenses is indicative of more effective special attentional processing, especially in more complex diagonal incongruent trials.

Conclusions

Our pilot study provides preliminary support to utility of wearing prism lenses to correct ambient vision in autism and sensitivity of ERP indices to detect visuospatial attention improvement. We have found that using prism lenses and comparing the autistic patient's performance and ERPs with and without such lenses can be a very informative approach to understand the mechanisms of visual deficits and spatial attention orienting impairments typical for autism.

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What Is Common and Unique in ADHD and Schizophrenia: Studies of Event-Related Potentials

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This presentation represents review of research of event-related potentials (ERPs) in attention deficit hyperactivity disorder (ADHD) and schizophrenia. The most common scientific observation is a decrease of the P3b wave both in ADHD and schizophrenia. This wave is usually evoked in the oddball paradigm in response to deviant rare targets when compared with responses to standard frequent nontarget stimuli. This observation appears to reflect a common dysfunction in ADHD and schizophrenia in the parietal attention system. Dopamine hypotheses of ADHD and schizophrenia will be discussed. The hypotheses imply involvement of different aspects of information processing within the basal ganglia thalamocortical circuits. A recently emerged independent component analysis (ICA) provides a powerful tool for decomposing ERPs into components of different functional meanings. This presentation describes results of applying ICA to decompose a collection of ERPs into independent components associated with different psychological operations (such processing in dorsal and ventral visual streams, orienting response, engagement, motor suppression, and conflict monitoring operations). One thousand healthy subjects, 1,000 patients with ADHD, and 100 patients with schizophrenia participated in this multicenter European study including laboratories from Switzerland (A. Mueller et al.), Norway (S. Hollup et al.), Macedonia (N. Pop-Jordanova

et al.), and Russia (Kropotov et al.). The results of application of the ERP ICA for diagnosis (discrimination) ADHD and schizophrenia from healthy subjects will be presented. In the final part of the paper, a methodology for constructing protocols of neurofeedback and transcranial direct current stimulation (tDCS) on the basis of comparison the individual ERP parameters with the normative data will be presented. Recently emerged methods of neurotherapy such as sLORETA-based, ERP-based neurofeedback and tDCS will be also introduced in relation to neuromodulation in ADHD and schizophrenia.

Financial Interest

The NovaTech company and Mitsar company are paying the travel fees to the ISNR conference. I am a co-owner of HBImed AG company (Switzerland).

Planning for a Collaborative Multisite, Double-Blind, Sham-Controlled Randomized Clinical Trial of Neurofeedback for ADHD

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Medication and behavior modification, the established treatments for attention deficit hyperactivity disorder (ADHD), are not universally effective or acceptable to all and have not been shown to have sustained effects beyond 2 years. The 8-year outcome paper (Molina et al., 2009) for the NIMH Multimodal Treatment Study of ADHD (the MTA) pointed out the need for new treatments with lasting effects. Among complementary/alternative treatments for ADHD, neurofeedback (NF) is one of the most prominent, despite its expense and technical difficulties. However, despite a meta-analysis of 6 randomized control trials (RCTs) with a large effect size (ES) for inattention and medium ESs for hyperactivity and impulsivity (Arns, de Ridder, Strehl, Breteler, & Coenen, 2009) and 16 RCTs with a mean medium ES for overall ADHD, inattentive, and hyperactive/impulsive symptoms, many of these studies are small and have not used adequate blinding. The results from the recent National Institute of Mental Health (NIMH)-funded Ohio State University feasibility pilot study indicated that a well-blinded large RCT of NF utilizing a sham control of equal intensity and duration is feasible and necessary, although questions have been raised about whether the sham placebo was truly inert.

As with any treatment, it is difficult to determine how much of the apparent treatment effect is specific to the treatment, and how much is placebo effect. Two small studies (Perreau-Link, Lessard, Levesque, & Beauregard, 2010 [$N = 8$]; and Lansbergen et al., 2011 [$N = 14$]) published after the Arns meta-analysis had a blinded sham control and showed no advantage of NF over placebo, raising questions about the unblinded studies. These inconclusive scientific results pose a public health dilemma. The treatment involves considerable initial expense and lengthy commitment by the patients and families. However, if NF has lasting specific benefit, the initial cost and time may compare favorably with medication. Therefore, it is important to know whether NF has a specific effect beyond placebo response, whether the persistence of benefit can be replicated, and whether a biological endophenotype can be identified who will reliably benefit from it. Without resolution of the effectiveness question, this potentially valuable adjunct to the ADHD treatment armamentarium will not be fully utilized and widely accessible.

In November 2010, Drs. Gene Arnold, Roger deBeus, Larry Hirshberg, and Nick Lofthouse presented a symposium on ''EEG Neurofeedback for ADHD: Review of the Science and New Findings'' at the annual meeting of Children and Adults with Attention-Deficit/Hyperactivity Disorder. Chaired by Drs. Russell

Barkley and Ann Abramowitz, this symposium led to a discussion about the possibility of a large-scale, multisite, double-blind, sham-controlled RCT of NF for pediatric ADHD. This discussion continued with weekly telephone conferences involving a group of NF experts (Drs. Joel Lubar, Vincent Monastra, Cynthia Kerson, Henry Harbin, Roger deBeus, Larry Hirshberg, & Mr. Martijn Arns) and mainstream ADHD scientists (Drs. Gene Arnold, Keith McBurnett, Keith Conners, Helena Kraemer, & Nick Lofthouse). In April 2011, these discussions led to an agreed-upon preapplication letter of intent to NIMH for multimillion dollar funding of this project.

This proposed study is the first to involve planning and execution by both mainstream ADHD scientists (to ensure credible scientific rigor) and NF experts/advocates (to ensure credible and rigorous treatment). In such a study, it is essential that all stakeholders have input so that the results, whatever they are, will be credible to all. This proposal is significant and innovative at the scientific, clinical, and public health level. Scientifically, the lack of a large well-controlled, double-blinded examination of NF has been a critical barrier to progress in the field, with disagreement between NF and most mainstream ADHD investigators about interpretation of the available data. On a clinical and public health level, testing of this promising treatment in a way that is rigorous in both clinical method and research design is greatly needed to see whether NF is an effective alternative treatment option for the many youth who do not respond to or refuse current evidence-based treatments and to see if NF holds additional promise as a complimentary treatment option.

This 60-min oral presentation will present the theoretical, scientific, clinical, and public health background for the proposed study and discuss the collaborative team's agreements, disagreements, and resolutions in developing the NIMH letter of intent. The study's main objectives, specific hypotheses, design, participants, instruments, and procedures will also be reviewed. Finally, we will report whether our efforts to obtain NIMH funding were successful, and the next step in our collaboration.

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How Reliable Is the Resonance Frequency?

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Introduction

Lehrer and colleagues (2004) proposed that each client has a unique breathing rate, called

the *resonance frequency*, at around 6 breaths per minute. Heart rate and blood pressure oscillations are 180 degrees out of phase, the baroreflex is strongest, and respiratory sinus arrhythmia is greatest at this respiration rate (DeBoer, Karemaker, & Strackee, 1987). Because training clients to breathe at their resonance frequency is a crucial component of heart rate variability (HRV) biofeedback, it is important that these measurements are reliable. *Why train a client to breathe at 5.5 breaths per minute today if her resonance frequency will be 6.5 breaths per minute next week?* The present study examined the 2-week test–retest reliability of resonance frequency measurements using a modified version of a protocol developed by Lehrer and Gevirtz.

Method

Participants. Nineteen undergraduates (16 male, 3 female), 19 to 22 years of age, participated in this study.

Apparatus. A Thought Technology ProComp™ Infiniti system detected the EKG using an Infiniti EKG™ sensor with leads placed on the upper chest and below the sternum, and measured respiration rate using a Resp-Flex/Pro™ sensor placed around the abdomen at the level of the navel. BioGraph Infiniti™ software measured the resonance frequency, 3 global indices of HRV (HR Max–HR Min, pNN50, and SDNN), and the LF/HF ratio. The resonance frequency is the breathing rate that produces the greatest synchrony between respiration band and instantaneous heart rate signals and that maximizes the most global measures of HRV. *HR Max–HR Min* is the difference between the highest and lowest heart rates during each respiratory cycle. The *pNN50* index calculates the percentage of adjacent N-to-N intervals that differ from each other by more than 50 ms. *SDNN* is the standard deviation of the interbeat interval for all normal sinus beats measured in milliseconds. The *LF/HF ratio* represents the percentage of power in the low-frequency band divided by the percentage of power in the high-frequency band.

Procedure. Subjects sat upright in a straight-backed chair with eyes open throughout this study. Following a 10-min resting baseline without feedback, we instructed subjects to follow an animated pacing display designed to guide their breathing from 7.5 to 4.5 breaths per minute in 7 descending $\frac{1}{2}$-breath-per-minute steps. Subjects breathed at each target rate for 2 min, followed by a 1-min buffer period. We retested all subjects using the same procedure 2 weeks later to assess the reliability of these measurements. They received no HRV training or breathing practice during the intervening period.

Results

We measured 2-week test–retest reliabilities measured using a Pearson product-moment correlation coefficient. We assessed the global HRV indices and HRV frequency components while our subjects breathed at their resonance frequency.

Resonance Frequency. Resonance frequency measurements were reliable, $r(17) = 0.73$, $p = .000$.

Global HRV Indices. While HR Max–HR Min measurements were unreliable, both pNN50, $r(17) = 0.65$, $p = .002$; and SDNN measurements, $r(17) = 0.59$, $p = .008$, were also reliable.

HRV Frequency Components. Although the VLF, LF, and HF measurements were unreliable, the LF/HF ratio was reliable, $r(17) = 0.58$, $p = .009$.

Discussion

Resonance frequency measurements achieved acceptable 2-week test–retest reliability. Among the global HRV indices, SDNN and pNN50 measurements were also reliable, whereas HR Max–HR Min was not. Among the HRV frequency components, the LF/HF ratio was reliable, but VLF, LF, and HF were not. These findings support protocols that train clients to breathe at their unique resonance frequency to maximize HRV. Because our subjects were primarily healthy male undergraduates, researchers should replicate these findings with

a gender-balanced clinical population to ensure external validity.

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The Effects of Heart Rate Variability on Sensorimotor Rhythm: A Pilot Study

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Heart rate variability (HRV) training and electroencephalographic (EEG) biofeedback are techniques that have been used to improve neurological disorders, such as attention deficit hyperactivity disorder (ADHD), as well as to optimize performance in athletes. HRV is a measurement of the variation in the respiration rate at which the heart is beating. Vaschillo, Lehrer, Rische, and Konstantinov (2002) call the low-frequency range 0.05 to 0.15 Hz, which generally corresponds to 5 to 6 breaths per minute and assumes respiratory sinus arrhythmia (RSA). The calculation for 6 breaths per minute is 6/60 sec which is equal to 1/10 or .1. RSA describes the relationship between heart rate changes and increased heart rate during inhalation and decreased heart rate during exhalation. Resonance found between these frequencies for breathing and heart rate variations relate to the heart rate closed loop of the baroreflex system, through which blood pressure changes are regulated. This specific signature of breathing and heart rate changes being synchronized may correlate with a more relaxed cognitive clarity. Improvements in cognition (Vaschillo et al., 2002) and emotional stability (Applehans & Luecken, 2006) have been demonstrated as a result of HRV training. A similar mental state is the target of EEG biofeedback training to increase sensorimotor rhythm (SMR 12–15 Hz across the sensorimotor strip C3, Cz, C4). SMR has been closely linked to a quieting state of calm relaxed focus (Sterman, 1996). In 2010, M. Thompson, Thompson, and Reid developed the systems theory of neural synergy, which outlines a link between HRV and brain function. In this paper, we discuss a link between HRV and sensorimotor response (SMR). We propose that training for increased HRV can lead to increased levels of SMR. At the ADD Centre, Dr. Lynda Thompson and Dr. Michael Thompson have been combining EEG biofeedback with physiological biofeedback, including respiration and heart rate training. The authors of this paper, while working with clients at the ADD Centre, noticed that many clients, including athletes, were showing increased SMR during sessions when they were training to achieve synchrony between respiration and heart rate changes (HRV training). This observation lead to the hypothesis that HRV training may enhance increases in SMR.

Method

Preliminary data have been collected for 10 clients ($n = 10$). Five clients were athletes training to improve performance, and five clients were from a clinical population aiming to increase SMR as a part of their program. The age range in this study was age 6 to 60. Three-min EEG assessment data were collected and artifacted at Cz for each client. Statistics were selected to measure mean microvolt values for SMR (12–15 Hz). Electromyogram (EMG) was also measured to ensure that the reflection of EMG on EEG (muscle artifact) did not act to artificially increase SMR. A second 3-min sample of EEG was collected during 3 min of HRV training, during which the client demonstrated HRV and synchronous RSA. Clients had to achieve a peak frequency heart rate between .05 and .15 during HRV training to be included in the study. The authors expect to collect data for 20 more clients during the next few months.

Results

Mean microvolt values were collected for SMR during the baseline recording and during the HRV training. All clients demonstrated an increase in SMR during HRV training as compared to baseline measures. *T* tests were done on the data, which showed $p < .01$. This demonstrates that the increase in SMR during HRV training is statistically significant.

Discussion

The preliminary results suggest that HRV training can lead to increases in SMR. These results have implications in the clinical setting. Clients with neurological disorders such as ADHD, seizure disorders, and Asperger's syndrome who are working towards increasing SMR may benefit from combining this neurofeedback training with HRV training. This combination of biofeedback and neurofeedback may lead to better clinical outcomes, possibly in less time.

HRV training gives the athletes more flexibility in controlling their autonomic nervous systems and thereby allows them to better regulate their emotional states during sports performance, which is a critical tool during a high stress performance. Breathing at one's resonant frequency can help maintain a calm, relaxed focus in the body and mind. SMR has been closely linked to a quieting state of calm relaxed focus (L. Thompson & Thompson, 1998). This study suggests that, by training HRV and SMR, athletes can obtain synergy between body and mind and thereby reach a more ideal performance state.

Based on the preliminary results of this study, practicing HRV training with clinical populations and with athletes is associated with increases in SMR at the central location (CZ), which is associated with a calm and alert mental state. Future research could investigate the combination of SMR training with HRV training as an effective method/intervention for working with both clinical populations and athletes to ameliorate symptoms and optimize performance.

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Exact Low-Resolution Electromagnetic Brain Tomography (eLORETA) of Adult ADHD: Pre/Post Findings Following Neurofeedback Therapy

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Introduction

Attention-deficit/hyperactivity disorder (ADHD) is one of the most common disorders of childhood with a cumulative incidence of 7.5% by 19 years of age (Barbaresi et al., 2004). The primary symptoms of ADHD include inattentiveness, impulsivity, and hyperactivity, which

persist into adulthood for 4 to 5% of patients (Goodman & Thase, 2009). EEG/QEEG analysis of adults with ADHD compared to healthy controls and/or normative database populations have produced a variety of patterns of activity, highlighting the heterogeneity of this population (Bresnahan, Anderson, & Barry, 1999; Bresnahan & Barry, 2002; Clarke et al., 2008a, 2008b, Hale et al., 2009; Koehler et al., 2009; Loo et al., 2009; Thompson & Thompson, 2005; White, 2001, 2003). The objective of this study was to investigate the specific frequency band pass regions and spatial locations associated with adult ADHD using exact low-resolution electromagnetic brain tomography (eLORETA) in comparison to healthy controls and following 30 sessions of neurofeedback therapy.

Method

Continuous 19-channel EEG was acquired from 40 adult participants that met *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; American Psychiatric Association, 1994) criteria for ADHD (combined, inattentive, or hyperactive type), without additional serious physical, neurological, or psychiatric disorders, and a full-scale IQ greater than 80. EEG recordings were collected at pre/mid/post-follow-up treatment intervals and included EO, EC, P300, and CNV tasks, as well as ADHD behavioral questionnaires. eLORETA analysis was computed on 2 min of EC data (Pascual-Marqui, 2002). The eLORETA output data were compared with age-matched individuals in a healthy control database (Nova Tech EEG, Mesa, Arizona, USA) using a multiple comparison procedure for the following frequency bands: absolute and relative power in delta (1–3 Hz), theta (4–7 Hz), alpha (8–12 Hz), beta1 (13–18 Hz), beta2 (19–21 Hz), beta3 (22–30 Hz); alpha and theta bands adjusted to individual alpha peak frequency (Pascual-Marqui, 2002; The KEY Institute for Brain-Mind Research, Zurich, Switzerland). Pre–post changes in the sources of EEG rhythms were also assessed following 30 sessions of Theta/Beta or slow cortical potential neurofeedback training.

Results

This investigation is part of a long-term treatment study currently in progress. The most current results related to eLORETA EEG source localization of adult ADHD patients compared to a control population and following 15 sessions of neurofeedback therapy will be presented at the time of the conference.

Conclusion

Analysis of eLORETA current source activities in adult ADHD patients compared to healthy controls and following neurofeedback training has not previously been investigated and may yield valuable insights related to alternative treatments for this population. Specific findings will be discussed and implication in the current treatment study, and future research will be explored.

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LORETA Neurofeedback and the Precuneus

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Introduction

This study examined the cortical effects of LORETA neurofeedback (LNFB) in the precuneus as a potential target region of training for substance abuse and attention deficit disorders. We evaluated pre- and posttraining current source density in the region of training and the network effects of 20 sessions of LNFB in the left precuneus. We assessed training effects using the Personality Assessment Inventory (PAI) and Delis-Kaplan Executive Function System (D-KEFS) pre- and posttraining.

Methods

Four undergraduate students, with a mean age of 24 completed 20 sessions of LNFB training in the left precuneus. The training consisted of 5 sessions per week with six 5-min training rounds within each session. The effects of LNFB were assessed with D-KEFS and PAI posttraining. We utilized a linear mixed model with repeated measures to analyze the effects of LNFB on current source density levels within the default network.

Results

The region and frequency of training shows a significant increase in current source density (CSD) as a result of LNFB. Network analyses show increases in left BA 3, 6, 7, and frontal regions with a corresponding decrease in right amygdaloid regions including BA 34, 28, and 35. Delta CSD is shown decreased in left BA 44, theta shows increased CSD in right BA 46, and alpha shows increased CSD in right BA 45, whereas beta shows maximal increased CSD in left BA 10. Perceptible changes in executive functions and personality assessment inventory scales are forthcoming.

Discussion

The data obtained in this study are part of a larger methodology to employ LNFB in treatment paradigms for substance use disorder and adult

ADHD. These results demonstrate LNFB in the precuneus to produce specific network increases and decreases between regions shown to be important to attention and self-regulation. In effect, decreases between network assemblies may reflect the direct effects of operant learning, such that less power is needed to produce the desired behavior. Numerous studies of neuroplastic changes associated with practice have shown similar effects and will be discussed. Thus, the current data demonstrate this to be a feasible method for larger clinical research trials and randomized control double-blind studies using LNFB methodology. Clinical implications are discussed.

STUDENT PRESENTATION

Deep Brain Modulations Guided by EEG Feedback Can Be Probed by Simultaneous fMRI

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Introduction

Decades of electroencephalogram (EEG)-feedback practice proved that people can be effectively trained to selectively modulate their brain activity. The premise of such a practice has been based on the idea that people can regulate their brain activity, thus improve its performance (Gruzelier, 2009; Peniston, Marrinan, Deming, & Kulkosky, 1993). A common protocol of EEG-feedback aimed to help people in relaxation is based on closed loop guidance by shifts from high-amplitude of alpha (8–14 Hz) to low-amplitude of theta (4–7 Hz) oscillations (Vogel, Foulkes, & Trosman, 1966) through training. The induction of such a shift in EEG oscillations has been useful in reaching a state of deep relaxation in psychiatric conditions of anxiety and mood disorder (Gevensleben et al., 2009; Lantz & Sterman, 1988; Peniston et al., 1993). However, the clinical implication of this practice in psychiatry remained elusive and considered of relatively low therapeutic yield, possibly due to its widespread cortical representations. The hurdle may lie in the poor spatial resolution of the EEG, thus precluding valid probing of deeper brain structures such as limbic regions that are critical for modulating emotional states. 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 the neural modulations induced via EEG feedback on shifts in alpha/theta ratio.

Methods

Fifteen healthy subjects participated in a pre-scanning 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, which alternates between increasing and decreasing the alpha/theta ratio (i.e., inducing neural modulation. BrainVoyager, EEG-Lab and at-home software packages were used for preprocessing and analyzing the raw brain signals in correspondence to induced mental states).

Results

A general linear model for the whole brain using the changing mental states as predictors was calculated. Defined contrast between eyes closed wakefulness and eyes closed relaxation revealed two intriguing brain areas. While the subjects relaxed, the superior frontal gyrus was more active and the subgenual cingulate cortex was deactivated.

Conclusions

Simultaneous fMRI during EEG feedback via alpha/theta ratio modulation probed activation variation in deep brain limbic area such as the subgenual cingulate cortex. This limbic area is known to play a role in generation of affective states presumably mediated by parasympathetic autonomic tone (Critchley, 2005), which might lead decreased focal activation. An extensive work in the last

decade points to alterations in this area activity in major depression and to the moderating effect of its focal electrical stimulation. The recruitment of the superior frontal gyrus as relaxation took place fits its proposed role in moderating high arousal (Beauregard, Levesque, & Bourgouin, 2001) in emotional self-regulation. Altogether our results clearly demonstrate the advantage in combining EEG and fMRI for optimizing neurofeedback procedure at the individual level. Methodological and practical aspects of such approach will be further discussed.

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KEYNOTE PRESENTATION

Molecular Development of Projection Neuron Types and Building of Local Microcircuitry in the Cerebral Cortex

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The activity and function of the mammalian cerebral cortex rely on the integration of an extraordinary diversity of excitatory projection neurons and inhibitory interneurons into balanced local circuitry. The developmental events governing the proper interaction between excitatory projection neurons and inhibitory interneurons are poorly understood. Here, we have first investigated the function of the transcription factor Fezf2 in controlling the fate-specification of corticofugal projection neurons (CfuPN) of the neocortex. We find that Fezf2 acts as a powerful master gene that is sufficient to instruct the birth of CFuPN even from progenitors fated to become medium spiny neurons in the striatum. Secondly, we report that different subtypes of projection neurons uniquely and differentially determine the laminar distribution of cortical interneurons into cortical layers. We find that in Fezf2-/-cortex, the exclusive absence of subcerebral projection neurons and their replacement by callosal projection neurons cause distinctly abnormal lamination of interneurons. This results in physiological imbalance of excitation due to altered GABAergic inhibition. In addition, experimental generation of either corticofugal neurons or callosal neurons below the cortex is sufficient to recruit cortical interneurons to these ectopic locations. Strikingly, the identity of the projection neurons generated, rather than strictly their birth date, determines the specific types of interneurons recruited. These data demonstrate that in the neocortex individual populations of projection neurons cell-extrinsically control the laminar fate of interneurons and the assembly of local inhibitory.

The NIMH-Funded OSU Randomized, Double-Blind, Sham-Controlled Pilot Feasibility Trial of Neurofeedback for Pediatric ADHD—Complete Results

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Introduction

The established treatments for attention-deficit/hyperactivity disorder (ADHD) are not universally effective or acceptable to all, and have not been shown to have sustained effects beyond 2 years. The 8-year outcome paper (Molina et al., 2009) for the NIMH Multimodal Treatment Study of ADHD (the MTA) pointed out the need for new treatments with lasting effects. Among complementary/alternative treatments for ADHD, neurofeedback (NF) is one of the most prominent, despite its expense and technical difficulties. A meta-analysis of 6 randomized clinical trials (RCTs) reported large effects on inattention and medium effects on impulsivity and hyperactivity (Arns, de Ridder, Strehl, Breteler, & Coenen, 2009). However, the control conditions were not blinded and often not of equal duration and intensity compared to the NF conditions. Preparing for a definitive RCT, this pilot study explored feasibility of a double-blind, sham-controlled design and compliance/palatability/relative effect of 2 versus 3 treatments/week.

Method

Unmedicated 6- to 12-year-olds with *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; American Psychiatric Association, 1994) ADHD were randomized to active- NF or sham-NF (2:1 ratio) and to 2X versus 3X/week (wk) treatment frequency (1:1) for 40 treatments (Tx). Switch of Tx frequency was allowed after Tx 24. Multi-informant assessments at baseline, treatments 12, 24, and 40, and 2-month follow-up included preferences/satisfaction, caregiver ratings, and objective tests.

Results

Of 39 randomized; 3 dropped by Tx 6, 2 after Tx 22; 86% completed all 40 Tx. At 40th Tx, child and parent guesses about assigned Tx were worse than chance. At Tx 24, of 34 families continuing, 13 (38%) chose 2 Tx/wk; 21 (62%) chose 3 Tx/wk. Of 8 experiencing both frequencies, no children and 1 parent preferred 2X/wk. Parent/teacher rated ADHD symptoms were as good with 3X/wk as 2X/wk. In the active Tx, improvement asymptoted by Tx 24. Both active NF and sham yielded large pre-post improvement on parent ratings, but NF no more than sham.

Conclusions

Compliance/completion was acceptable. 3X/wk Tx frequency seems preferred over 2X/wk and is as effective. Blinding appears to work. Thirty treatments appeared adequate for maximal benefit. In view of the large placebo effect compared to unblinded positive results in the literature, a large double-blind RCT is necessary to test specific effectiveness.

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American Academy of Child and Adolescent Psychiatry, *48*, 484–500.

Why We Make Ourselves Sick and How to Make Ourselves Healthy: The Importance of Nutrition, Exercise and Sunlight

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E. Roy John and Leslie Prichep (2006) proposed an EEG Homeostatic Model for the brain. In this model, neurotransmitters mediate neuroanatomical structures that generate behavior regulated by emotional experience in the moment of the event. They proposed that ''psychological and neurological disorders produce and are caused by deviations from homeostasis'' (p. 135). If an environment or psychological challenge continues for an extended period, the set point for homeostasis adapts to a new point. This short course provides information about the importance of nutrition, exercise, and sunlight in the process of reestablishing EEG homeostasis. David Siever will review the literature concerning the effects of nutrition, exercise and sunlight on the brain, and Ron Swatzyna will present his EEG/QEEG study on the impact of breakfast patterns in children.

Nutrition affects oscillatory rhythms and neuronal functioning. Iodine boosts IQ and helps prevent mental retardation. Omega 3 s, selenium, and magnesium all improve mental function and reduce depression. Exercise has been shown to be highly effective for improving IQ, math ability, and reducing depression. Exercise should be a mandatory part of any academic program. Preliminary findings using QEEG suggest that what is eaten for breakfast has an effect on both mood and mental performance. As for the importance of sunlight, as much as 6% of northern populations are believed to develop winter blues. Depression, anxiety, insomnia, multiple sclerosis, migraine, seizure, fibromyalgia, and dementia are well correlated with a deficiency in vitamin D. Previous research has always assumed that winter blues was the result of seasonal affective disorder, which comes about as a lack of optic stimulation to UV receptors in the eyes and, ultimately, the pineal gland. There are several similarities in the symptoms of SAD and vitamin D deficiency, and therefore it is possible that SAD has been misdiagnosed since its inception. A recent study on vitamin D deficiency has shown that vitamin D supplementation eliminates the symptoms of SAD in SAD sufferers.

The human brain was never designed to be healthy; it was designed to survive. Despite the robustness of the brain, we are not sharp and productive, nor social, lively, and joyful unless we address good nutrition and exercise. We have to work at being mentally healthy. As long as we are ignoring our basic needs, the brain will do what it has to along a predictive pathological course to survive, and we will suffer. Active voluntary participation in good nutritional decisions, exercise routine, and outside activities (if possible) are necessary for EEG Homeostasis.

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Setting Up for Success with Asperger's and Autistic Spectrum Disorder

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Attendees at this presentation will become familiar with how symptoms differ between Asperger's and autism. They will be able to outline, on the basis of functional Neuroanatomy (which includes discussion of Brodmann Areas, neural networks, and connections, including vagal inputs to the medulla), why a combination of Neurofeedback (NFB) + Biofeedback (BFB) strategies improves social functioning in

addition to significantly improved scores on academic, intelligence, and attention measures. The authors' first talk at an International Society for Neurofeedback and Research meeting in 1995, ''Exceptional Results with Exceptional Children,'' included a case example of successful NFB training at Cz with a student with severe autism. This presentation gives an overview of how our interventions using NFB + BFB in clients with Asperger's and autistic spectrum disorders have evolved. Current interventions incorporate an understanding of the functional significance of different areas of the brain and neural networks. Functional significance of cortical areas is partially elucidated in Brodmann Areas booklet (Thompson, Thompson, & Wu, 2008). This talk expands on this to include brain networks that depend on cortical-basal ganglia-thalamo-cortical connections. These networks may account for the observation that training these clients over central midline structures (CMS) at Fz or Cz, may have effects on broader functional networks (affect, attention, executive, salience, and default networks). Having an effect on more than a single network is particularly important in this group of patients because they demonstrate symptoms that involve a number of different networks. The symptoms may include, in addition to their difficulties with social interactions, high anxiety, difficulties with attention and impulsivity, and specific learning difficulties. Regarding assessment, we discuss how high tactile sensitivity may mean we begin with only a single channel QEEG assessment and follow-up later with a 19-channel QEEG. EEG interpretations used to illustrate findings range from raw data to quantitative analysis with LORETA and, when possible, event related potentials. Participants will see commonly observed EEG and QEEG patterns including a very common presentation of excess frontal slow wave activity, a dip at Pz in the low alpha (8–10 Hz) range, and higher than expected low and high frequency beta. Correlation of findings to symptoms and networks is made and exceptions are noted. The QEEG findings are the basis for setting NFB parameters for training and common initial settings will be described. This is complemented by a discussion of the functional neuroanatomical basis for doing BFB, particularly heart rate variability (HRV) training, with NFB and why we also provide one-to-one coaching in metacognitive strategies related to both cognitive and social skills. The training addresses the symptoms that interfere with the child being able to interact constructively with caregivers including, in order: anxiety, impulsivity, attention span, executive functions, and finally understanding and responding to social cues.

Statistical Support

The pre–post training results for NFB over CMSs combined with BFB+ Metacognitive strategies includes results showing EEG, TOVA, IVA, Wechsler Intelligence Scale (WISC & WAIS), academic measures (WRAT), and questionnaires for 150 patients with Asperger's and 9 with Autism.

Financial Interest

Lynda Thompson is coauthor of *The A.D.D. Book*. Michael and Lynda Thompson are coauthors of *Setting Up for Clinical Success*. Michael and Lynda Thompson are co-authors of *The Neurofeedback Book*. It is likely that these books may be on sale at the meeting. The authors will state their interest in these books during the workshop.

The Effect of Neurofeedback and Cranial Electrotherapy on Immune Function Within a Group of HIV + Subjects: A Randomized Controlled Study

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Introduction

Modulation of the functional capacity of the immune system utilizing neurofeedback therapy may be expected given the many pathways and dense communication matrix mediating activity within and between the central nervous

system and the immune system. Those who promote cranial electrotherapy have stated that immune health is improved due to a decrease in negative mood states when using this device.

Method

This study investigated the effects of neurofeedback and cranial electrotherapy on a group ($n = 40$) of HIV+ male subjects between ages 18 and 55 over a period of 16 weeks. Subjects all had baseline T-4 helper cell (CD4+) counts of 200 to 400/cc (lab normal is 400 to 1770/cc). They were randomly assigned to 1 of 4 groups: neurofeedback only ($n = 10$), cranial electrotherapy only ($n = 10$), combined neurofeedback and cranial electrotherapy ($n = 10$), or a waitlist control group ($n = 10$). Subjects in the neurofeedback treatment condition were provided two 20-min sessions in the office each week. Neurofeedback was performed using linked ears (reference and ground) with the active electrode at the occipital midline, Oz (according to the International 10–20 system). Fast Fourier Transform using a Cooley-Tukey algorithm was applied to each 2.56-s epoch, and the square root of the absolute power coefficients were computed for each epoch. Subjects were rewarded by a tone when higher alpha amplitude (8–12 Hz) exceeded their initial testing amplitude (30 s with eyes closed). When subjects could sustain alpha amplitude at twice their baseline amplitude for 20 min, the reward tone was shifted to a lower theta-alpha frequency (6–8 Hz). Drowsiness was discouraged by inhibiting slower (4–6 Hz) activity as well as intervention by a technician who was actively monitoring EEG activity. If the EEG indicated sleepiness, a technician would verbally tell the subject to refocus on the tone. Subjects selected to use the cranial electrotherapy were provided an Alpha-Stim unit (Model 2000GL) along with detailed information on proper utilization of the device. Subjects agreed to use the unit at home as directed every day for 20 min. The combined group had both neurofeedback and cranial electrotherapy. The waitlist control group received neither neurofeedback nor cranial electrotherapy. Each subject remained in their respective condition continuously for 16 weeks. All subjects completed a stress audit questionnaire and symptom check list every week for the duration of the study. Also at the baseline, after 8 weeks, and after 16 weeks, subjects in all 4 groups had their blood drawn at their individual physician's office, which was then analyzed by independent laboratories. This provided CD4+ measurements that were statistically analyzed.

Results

A one-way analysis of variance was used to test for overall difference among groups for each dependent variable. This was followed by pairwise comparisons between groups using Dunnett's test. Results indicated that at baseline, basal total lymphocyte counts (CD4+) counts did not differ between groups ($p > .72$). After 8 weeks, CD4+ counts were significantly greater than controls for the combined group ($p = .01$) only. After 16 weeks, CD4+ counts were significantly greater than controls for the neurofeedback group ($p < .01$) and combined group ($p < .01$). There was no significant change in CD4+ count for the control and cranial electrotherapy only groups over the 16-week period. Results of the subjective stress and physical symptoms inventories corroborated the statistically significant changes in the neurofeedback and combined groups.

Conclusion

This pilot study suggests neurofeedback may be a promising tool to improve immune function and warrants further investigation. A replication study might better control for placebo effect bias and ensure compliance by having both conditions receive treatment in a clinical setting. Newly developed software that provides sham feedback would facilitate a stronger, double-blind placebo design. Last, although Oz was effectively trained to produce higher amplitudes within specified frequency ranges, recent literature suggests an even stronger effect may be seen using a Pz sensor placement.

INVITED PRESENTATION

Measuring Neural Correlates of Early Infant Behavior

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Complex mental disorders such as autism exhibit abnormal neural connectivity on many scales that varies between different regions of the brain. In the autistic brain, high local connectivity and low, long-range connectivity may develop concurrently due to problems with synapse pruning or formation. Similarly, epilepsy has been described as a heterogeneous spectrum disorder that is also characterized by abnormal neural connectivity in the brain. One might even say that all developmental brain disorders are neural connectivity disorders. Understanding and measuring brain connectivity is essential to finding neural correlates of behavior or psychiatric biomarkers.

The human brain contains on the order of 10^{11} neurons and more than 10^{14} synaptic connections. Although sparsely connected, each neuron is within a few synaptic connections of any other neuron. This remarkable connectivity is achieved by a kind of hierarchical organization that is ubiquitous in nature, called scale-free or complex networks. Complex networks are characterized by dense local connectivity and sparser long-range connectivity. Although EEG has long been a useful tool for clinical neuroscience, a great deal of information about the network structure of the nervous system likely remains hidden because linear analysis techniques fail even to detect them. Analysis of signal complexity and transient synchronization using nonlinear analysis and generalized synchronization methods may reveal information about local neural complexity and long-range communication between brain regions that will be clinically useful.

The development of novel EEG sensors with improved resolution, together with new source localization algorithms and methods for computing complexity and synchronization from EEG data promise continued improvement in the ability to measure subtle variations in brain function. Deeper understanding of the relationship between these neurophysiological processes and behavior may yield a new window into the mind, allowing us. Because atypical brain development is likely to precede abnormal behavior by months or even years, this may provide a critical developmental window for early intervention that may be missed if diagnosis is based entirely on a behavioral phenotype.

EEG Theta/Beta Ratio, EEG Vigilance, and Arousal in Adult Attention-Deficit/Hyperactivity Disorder: Reevaluation of Current Methods

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Introduction

EEG/QEEG analysis of adults with attention deficit hyperactivity disorder (ADHD) has produced a variety of activity patterns (Hale et al., 2009; Koehler et al., 2009; Loo et al., 2009; White, 2001, 2003) as well as the typical increases in theta/beta ratios seen in pediatric populations (Bresnahan, Anderson, & Barry, 1999; Bresnahan & Barry, 2002; Clarke et al., 2008). The theta/beta ratio has been considered a marker of nervous system arousal and is a cornerstone of current models of ADHD. However, this measure has not been validated and does not correlate with skin conductance level (SCL) in adolescent ADHD populations (Barry, Clarke, Johnstone, McCarthy, & Selikowitz, 2009). Recently the EEG Vigilance (Bente, 1964; Hegerl, Olbrich, Schönknecht, & Sander, 2008; Hegerl, Stein, et al., 2008) model has emerged to explain trait and state differences in clinical populations and refers to the pattern of distinct states of global brain activation observable on the continuum from full wakefulness to sleep onset during eye-closed resting state (Olbrich et al., 2009). Analysis of EEG Vigilance in a childhood ADHD population

indicated that individuals with ADHD have more frequent vigilance state shifts and tend to spend more time in lower vigilance stages (Sander et al., 2010). EEG Vigilance and heart rate was accessed in a control population and the average heart rate (HR) decreased as participants entered the lower arousal/vigilance stages (Olbrich et al., 2009). This study aims to test the theta/beta ratio, EEG vigilance, SCL, and HR as markers of arousal to investigate current ''arousal'' models of ADHD within an adult population.

Methods

Continuous 19-channel EEG, SCL, and HR were acquired from 20 adult participants that met *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; American Psychiatric Association, 1994) criteria for ADHD (combined, inattentive, or hyperactive type), without additional serious physical, neurological, or psychiatric disorders, and a full-scale IQ greater than 80. EEG recordings included EO, EC, P300, and CNV tasks. EEG vigilance clusters (A1, A2, A3, B1, B2/3 + C) and state changes were assessed in 1-min blocks over the 15-min eyes-closed recording in accordance with the latest version of the Vigilance Classification Algorithm originally presented by Hegel and colleagues (2008a). SCL, HR, and theta/beta (calculated as the ratio of theta [4–7 Hz] to beta [13–21 Hz] relative power at Cz) were also calculated for the 1-min blocks. For vigilance and theta/beta ratio, individual means were correlated with individual SCL and HR.

Results

This investigation is part of a long-term ADHD treatment study currently in progress. The most current results related to theta/beta ratios, EEG vigilance, SCL, and HR states in the adult ADHD populations will be presented at the time of the presentation.

Conclusion

Specific findings and study shortcomings will be discussed and current models of arousal in ADHD evaluated.

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QEEG-Guided Neurofeedback for the Remediation of Dysgraphia—An Outcome Study

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Twenty-five individuals, aged 6 to 51 years, all right-handed, presented at our clinic with a complaint of handwriting difficulty. Each of them had a quantitative EEG (QEEG). Our attention focused on the areas controlling motor planning (F3) and sensorimotor integration (C3) of the right hand. Eighteen of the individuals had excessive 1–10 Hz activity at C3, and 7 of them had excessive 1–10 Hz activity at F3, and 2 had excessive 21–30 Hz activity at F3. Those who had excessive 1–10 Hz at C3 underwent 5 sessions of training to decrease 1–10 Hz and increase 15–18 Hz at C3. Those individuals who had only excessive 1–10 Hz at F3 had 5 sessions to decrease 1–10 Hz and increase 5–18 Hz at F3. The 2 with excessive 21–30 Hz at F3 had training to decrease 21–30 Hz and increase 10 Hz at F3. Two individuals chose not to do neurofeedback. Handwriting was scored pre- and postneurofeedback with a modification of the Checklist of Written Expression, on a scale from 1/10 to 10/10. The results and statistical analysis will be discussed. The results were judged as good to excellent in all but 1 of the 23 subjects who did the neurofeedback training ($p < .01$).

ISNR 2011 POSTER ABSTRACTS

Transcranial Magnetic Stimulation (rTMS) Modulates Selective Attention and Executive Functioning in Autism

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Introduction

Autism spectrum disorder (ASD) has been previously shown by our group to be associated with abnormalities in later-stage event-related potential indices of selective attention. Specifically the attention-orienting frontal P3a and the sustained attention centro-parietal P3b have been found to be atypical in ASD during a visual oddball task. This may be related to reduced inhibitory tone of the dorsolateral prefrontal cortex (DLPFC) in ASD, as the DLPFC has been associated with selective attention and working memory. In this study we wanted to test the effects of bilateral low-frequency repetitive transcranial magnetic stimulation (rTMS) applied to the DLPFCs on novelty processing in ASD. We hypothesized that rTMS would improve cortical inhibitory tone by selectively activating inhibitory GABAergic double bouquet interneurons, and this would improve task performance.

Methods

We recruited 25 participants with ASD and randomly formed a 15-subject active TMS

group and a 10-subject waitlist group. We assessed task performance before and after 12 sessions of bilateral low-frequency rTMS in the active TMS group and before and after a 6-week waiting period in the waitlist group.

Results

Individuals with ASD showed significant improvement following treatment evidenced by improved P3b responses to targets and better stimulus discrimination. There was also a significant improvement in frontal reactivity to novelty as indicated by the P3a component. The waitlist group did not show any significant changes.

Conclusions

We propose that that low-frequency rTMS may have increased cortical inhibitory tone and subsequently improved performance in the novelty-processing task. TMS has the potential to become an important therapeutic tool in ASD treatment with few, if any, side effects.

EEG-Assessed Bandwidth Activity Differences Between Individuals with SCI with and Without Chronic Pain

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Chronic pain is a significant problem for many individuals living with a spinal cord injury (SCI). However, not all people with SCIs experience chronic pain as a direct result of the injury. Electroencephalograph (EEG) technology may be useful to understand possible differences in brain activity in individuals with SCI with and without chronic pain. The purpose of the current study is to measure and compare baseline brain activity between participants who experience daily SCI-related pain to those who do not. Seventy-one participants with SCI and chronic pain ($n = 42$), SCI without pain ($n = 13$), or with neither SCI nor pain ($n = 16$) underwent an EEG assessment. Participants with SCI and chronic daily pain exhibited slightly more relative fast wave activity (β-wave) and slightly less slow wave (α-wave) activity than participants with and without SCI who did not have pain. The alpha/beta ratio was significantly lower in participants with SCI and pain than participants without pain. The results suggest that the presence of pain is associated with brain activity as measured by EEG and supports the potential utility of EEG for identifying these differences. The findings also suggest the possibility that interventions that alter brain wave activity in persons with a SCI and pain, such as neurofeedback training, could influence the experience of pain.

Asymmetrical Frontal Gamma Activity During a Telekinesis Demonstration

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Early this year we had the opportunity to observe a demonstration of ''telekinesis'' with EEG monitoring for a reality TV show. We utilized the Hilbert-Huang transform (HHT), a new method to construct a sharp and clean time-frequency spectrum of a nonlinear and nonstationary signal. Using empirical mode decomposition while retaining intrawave modulation makes it very suitable for quantitative EEG analysis; also, HHT has excellent potential for clinical EEG neurofeedback, as will be presented. Using HHT analysis we discovered that coincident with the mentalist apparently moving a pen in a glass without touch (but not under control conditions), there was a sharp rise in left frontal gamma activity with no corresponding rise on the right. These nonblind observations will not convince skeptics (including ourselves), but they do open a path for open-minded rigorous evaluation of the phenomena that were observed.

Factors Related to Income, Quality of Work Life, and Burnout for Neurofeedback Practitioners

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Introduction

Research on neurofeedback therapy (NFT) practitioner variables that influence outcomes is still in a nascent phase. Larson, Ryan, and Baerentzen (2010) investigated NFT practitioner perspectives. They utilized a systematic, qualitative method to analyze survey data from 71 practitioners. These authors captured practitioner perspectives on the advantages and disadvantages of NFT and on the knowledge, skills, and personality traits necessary to be a successful NFT practitioner. They reported three major findings. They found that practitioners generally view ongoing NFT as effective in reducing symptoms and improving quality of life. They found that practitioners view commitment to NFT as essential for overcoming the complexity of NFT. They identified 34 personality traits practitioners endorse as essential. This current study sought to build off of these previous findings to add to the research base on NFT practitioner perspectives with the goal of identifying practitioner variables that may influence practitioner outcomes. From these previous findings, we hypothesized commitment, knowledge, inquiry/intake ratio, successful outcomes, supervision, training, dropouts, traits, and caseload are associated with quality of work life, burnout, and income.

Method

We utilized an online survey system to collect surveys from 238 NFT practitioners to engage them in the process of identifying factors related to NFT. We contacted practitioners through e-mail and discussion boards, and each practitioner was asked to complete an online survey. For each survey completed, $10 was donated to a neurofeedback professional organization research fund. The survey included questions about demographics and variables identified in our previous research. Practitioners were also asked to choose 10 traits that best described them from the list of 34 traits identified in the previous study (Larson et al., 2010). We utilized SPSS descriptive statistics for our demographic and NFT experience information. We completed independent sample *t* tests with Bonferroni correction, crosstab chi-square analyses, Cronbach's alpha tests, regression analyses, and slope plotting.

Results

Preliminary findings indicated burnout scores are negatively associated with quality of work life (QOWL). QOWL scores are positively associated with using neurofeedback in practice. Non-NFT methods in practice are negatively associated with QOWL. We also found that QOWL scores are associated with commitment to understanding brain function, learning new NFT techniques, and improving interpersonal skills. We found income rates are positively associated with providing supervision/training, inquiry/intake ratio, sessions per month, and successful outcomes. Moreover, of the 34 neurofeedback practitioner traits identified in previous research, frequency analyses indicated the highest endorsed traits in rank order were (1) ethical, (2) attentive, (3) empathic, (4) accepting, (5) calm, (6) observant, (7) sense of humor, (8) analytical, (9) confident, and (10) realistic expectations.

Conclusions

These data support the notion that single focus commitment to NFT is a requisite for a socially, emotionally, and financially satisfying experience of neurofeedback practice. An eclectic approach in which neurofeedback is used occasionally may dilute practitioner proficiency; subsequently impacting NFT-related revenue and zest for a personally involved intervention. It may be that the complexity of NFT contraindicates delving into other treatment modalities. Alternatively, NFT may attract individuals with a tendency to temporarily adopt novel

approaches. Dedicated commitment to lifelong training in physiology, cognition, learning, and statistics may moderate the relationship between emotional satisfaction and financial reward. It seems reasonable to hypothesize that dedicated commitment, emotional satisfaction, and financial reward each affect practitioner competency.

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EEG/LORETA Frequency and Localization Characteristics of Compassion versus Egocentrism versus Universal Mind

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There appears to be an epidemic of human violence in the world today, with more than 37 violent conflicts currently under way worldwide. One way of combating violence is the installation of compassionate attitudes and behaviors in human beings. In an effort to better understand and to promote compassion, the present study examines EEG cortical neuroimaging during compassionate versus self-centered versus universal mind meditations among a cohort of 60 young adults. Outcomes indicate, uniquely for the compassion meditators, significant enhancements of slow wave (Theta/Low Alpha EEG frequencies) activity in brain regions involved in emotional inhibition, verbal self-memory, emotional processing of sensory experiences, sensorimotor short-term memory, and auditory processing, consistent with the scripted compassion constructs contemplated. Such an activation of specialized brain regions during compassionate meditation suggests unique cortical localizations and neuroelectrical frequencies involved in compassion. Implications are explored for the enhancement of compassionate behaviors and attitudes via directed site- and frequency-specific neurotherapy.

A Randomized Trial of Computer Attention Training in Children With Attention-Deficit/Hyperactivity Disorder

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Introduction

We report preliminary results from a study in 17 schools examining the efficacy of 2 computer-based attention training systems in teaching children with Attention Deficit/Hyperactivity Disorder (ADHD) to concentrate more effectively. Several studies suggest that attention training using neurofeedback may result in decreased symptoms of ADHD and improved academic performance and behavior at school. In one such study of 100 children on stimulant medication (Monastra, Monastra, & George, 2002), only the participants who received additional neurofeedback sustained the positive gains after the stimulant medication was discontinued. A small, randomized controlled trial of neurofeedback with a waitlist control (Linden, Habib, & Radojevic, 1996) demonstrated improvements in behavioral symptoms of ADHD. Unfortunately, there were only 18 participants, so there was insufficient power to demonstrate a statistically significant difference between the groups. We compared a neurofeedback (NFB) computer attention training system that teaches children to alter their brainwave activity with a Standard Computer Format attention training system (SCF). We hypothesize that both treatments will show improvement in ADHD symptoms and academic outcomes compared to a control condition.

Methods

Forty-five children with ADHD in Grades 2 and 4 were randomly assigned to receive the NFB, SCF, or a waitlist-control condition (WLC) that

receives NFB or SCF the following academic year. Children received forty 45-min sessions 3 times a week at school for 4 months. As part of a comprehensive assessment, we report data on the T-SKAMP completed by teachers that assesses symptoms of ADHD in the classroom; the PERMP, a math test completed by students that analyzes speed and accuracy; and the BOSS, double-blind classroom observations.

Intervention/Program/Practice

The neurofeedback intervention system used is commercially available and was chosen for several reasons: (a) The NFB component is directed at increased theta waves and decreased beta waves in the frontal cortex, which are the most frequently observed cortical deficits in children with ADHD, and (b) it uses EEG sensors that are embedded in a bicycle helmet, as opposed to EEG sensors placed directly on the scalp with wires, which significantly eases delivery in children. This system includes different tasks to train attention stamina, visual tracking (as required in the classroom), increased time-on-task, short-term memory and sequencing, and discriminatory processing. As the child advances, she or he progresses to more challenging tasks that include visual and auditory distractions, such as colorful shapes moving around on the screen and background noise. The SCF intervention used is also commercially available and was chosen for several reasons: (a) It includes an extensive array of cognitive exercises that target many areas of attention as well as working memory, and (b) the SCF system is designed to improve sustained concentration and working memory through a variety of specific interactive exercises manipulated with a standard computer mouse and keyboard. The exercises aim to maximize attention, decrease impulsivity, and train auditory and visual working memory. The tasks become more challenging as the participant progresses.

Results

Wave 1 participants include 41 children diagnosed with ADHD in Grades 2 and 4. We conducted preliminary analyses of variance of the PERMP, T-SKAMP, and BOSS (see Tables 3 and 4, Appendix B, in the paper). The NFB intervention group showed improvement on the number of math problems correct on the PERMP math test ($p = .03$), indicating an increase in accuracy as well as an increase in number of problems attempted on the PERMP math test ($p = .02$), illustrating an increase in speed. The NFB intervention group also demonstrated a decrease in ADHD symptoms as reported by teachers on the T-SKAMP Attention scale ($p = .01$). The SCF group showed improvement on the number of problems correct on the PERMP math test ($p = .01$) indicating an increase in accuracy, and a trend toward decreased ADHD symptoms on the T-SKAMP. The WLC showed no significant effects on either the PERMP or the T-SKAMP. The BOSS showed a trend toward ADHD symptom reduction in the classroom setting.

Conclusion

Our preliminary data from a 4-year study evaluating the efficacy of 2 computer-based attention training systems in schools shows significant results and promising trends. As this is a preliminary analysis of preliminary data, we have not addressed all of the study's aims and have not yet compared data between the 3 intervention groups. Teacher report of ADHD symptoms, math achievement by students, and objective classroom observations for our first wave were analyzed. Our preliminary data on these outcome measures suggest that computer-based attention training programs offered in an elementary school setting may be effective in reducing symptoms of ADHD and improved math achievement. We hope that analysis of full data collected after the intervention of Wave 2 will consolidate our findings and further explore the feasibility and effectiveness of computer attention training as a method to support children with attention issues in schools.

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Application of Quantitative Electroencephalogram and Neurofeedback in General Neurology Practice

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Despite major advances in computer technology, quantitative electroencephalography (QEEG) has been underutilized in general neurology practice for uncertain reasons. EEG-biofeedback (also called neurofeedback) has had very limited application in U.S. neurology practice because it has been frequently called experimental, thus not reimbursable by most health insurances. Therefore, this study was conducted to evaluate the clinical usefulness of QEEG and neurofeedback in general neurological practice. Over the period of approximately 9 months, 150 consecutive patients' QEEG recordings were analyzed for potential clinical benefits. QEEG patients were divided in 5 groups based on their initial clinical presentation. The main groups included patients with seizures, headaches, head injury, cognitive problems, and behavioral dysfunctions. Subsequently, patients' cases were reviewed and a decision was made whether QEEG analysis contributed to the diagnosis and/or further patient treatment. Selected and representative cases from each group are presented in more detail, including QEEG data, with additional low-resolution electromagnetic tomography analysis (LORETA) and/or using computerized cognitive testing. Statistical analysis showed that QEEG analysis contributed to most (more than 90%) neurological cases, which indicates great potential for wider application of this modality in general neurology. Many patients were also started with neurofeedback therapy, depending on the patient's desire to be involved in this treatment modality. Preliminary results of effectiveness of neurofeedback treatment are presented.

Memory Deficit and Malingering: An ERP-Based Assessment With a ''Dual-Probe'' Protocol and Countermeasure Use

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Introduction

Memory deficit is one of the most common symptoms accompanying many psychological/neuropsychological conditions. In traumatic injury cases (like closed head injury) where monetary compensation can be claimed, the potential motivation to exaggerate memory deficit increases. Thus, it often becomes difficult to estimate actual memory deficit. Literature shows that estimates of malingering reach up to 50% for malingered psychological symptoms. The large number of articles published on the topic demonstrates the concern among clinicians that successful malingering does take place. An event-related potential (ERP)-based memory deficit tests reveal a high level of resistance to the effects of malingering compared to behavioral tests of memory. Our previous studies demonstrated effectiveness of the Complex Trial Protocol (CTP) to detect concealed information (Rosenfeld & Labkovsky, 2010). The CTP hit rates range from 84 to 100%. Sometimes results are inconclusive because either the difference in P300 amplitudes between ''Probe'' and ''Irrelevants'' does not reach significance or due to excessive artifacts. To address this issue, a novel ''Dual-Probe'' protocol was developed.

Methods

The original CTP utilizes only 1 probe (which is a relevant/familiar to the subject item). Rare ''Probe'' or frequent ''Irrelevant'' (irrelevant/unknown to the subject stimulus) appears on

screen first and is followed by either Target or Nontarget in the same trial. Subject's birth date was Probe1 (P1) and Irrelevants were 4 other dates. Four strings of numbers were Nontargets and 1 string Target. There was no probe in the second part. In ''Dual-Probe'' CTP the first part is exactly as the original CTP, but in the second part, target/nontarget numbers were replaced with probe/irrelevant/target city names. Subjects' hometown was Probe2 (P2), and there were 3 irrelevant city names and a Target. Subjects randomly pressed 1 of 5 buttons on one response box to a date, and they pressed 1 of 2 buttons on another response box to a city name. We tested 3 groups ($N = 36$). Simple Guilty (SG), $n = 13$ (with P1 & P2); Innocent (IN), $n = 12$ (no probes); and Countermeasure (CM), 2 (of 4) ''Irrelevants'' in 1 part were countered. The CMs were the subject's silent, mental imaging of his or her first name (CM1) and last name (CM2). After a subject saw a to-be-countered irrelevant in the first part of a trial, he or she had to mentally state first or last name before randomly pressing 1 of the 5 buttons—''left hand'' response. Subjects were instructed to perform countermeasures so that the experimenter could not detect the silent, mental act.

Results

Hit rates: SG-13/13 total. Two subjects were ''caught'' with only 1 probe and the rest–with both P1 & P2. IN–1/12 false positive (only P1). CM-11/11 total, 2 subjects with only 1 probe and the rest with both P1 & P2). An analysis of variance on P300 amplitudes (3 groups $\times$ 4 stimulus type) revealed no group difference, $F(2, 33) = 2.233$, $p = .123$; significant stimulus effect, $F(3, 99) = 22.749$, $p < .000$; and significant interaction $F(6, 99) = 8.661$, $p < .000$. T test revealed significant difference between P1 and Iall1 amplitudes in SG, $t(12) = 5.472$, $p < .000$, and CM, $t(10) = 5.825$, $p < .000$, and no difference in the IN, $t(11) = 0.733$, $p = .479$. Significant differences were found between P2 and Iall2 in SG, $t(12) = 5.37$, $p < .000$, and CM, $t(10) = 5.793$, $p < .000$, and no difference in the IN, $t(11) = -2.146$, $p = .055$.

Conclusions

The ''Dual-Probe'' ERP-based protocol for assessment of memory deficit and malingering shows a high level of accuracy. Even when mental countermeasures are implemented by subjects to alter their ERP results, the Dual-Probe approach reflects the subjects' ability to recognize familiar/learned stimuli. Thus, the Dual-Probe protocol can be used in situations where subjects are unable, or unwilling, to report their recollection for learned material. Further research is required to investigate how introduction of countermeasures to the second part of a trial might affect the Dual-Probe protocol accuracy.

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Neurofeedback Training for the Enhancement of Attention in ADD/ADHD Children

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The phenotypical expression of Attention Deficit Disorder (ADD)/Attention Deficit Hyperactivity Disorder (ADHD) is complex and includes impairments in executive functioning, impulsive behaviors, and pervasive difficulties with inattention—areas that are critical to successful academic performance. Neurophysiological measures, including electroencephalography (EEG) that records the electrical activity of the brain, provide objective data to distinguish individuals with attention deficits from others (Doehnert, Brandeis, Straub, Steinhausen, & Drechsler, 2008). The most salient feature found in the EEGs of students with ADD/ADHD is

that of cortical slowing or an overabundance of slower brainwave patterns (Doehnert et al., 2008). These patterns are associated with distractibility, inattention, and daydreaming. Neurofeedback is often used to train students to produce faster brainwave patterns, similar to those of typically developing individuals, and has been found to be conducive to learning. A best-evidence analysis of existing research was conducted on the efficacy of neurofeedback as an intervention for enhancing attention in students with ADD/ADHD. Initially, 135 studies on neurofeedback were examined, with 113 being excluded for insufficient data, leaving 22 to be matched for compliance with preestablished criteria: studies limited to children, subjects matched with diagnostic criteria established by the American Psychiatric Association (1994; *Diagnostic and Statistical Manual of Mental Disorders*, 4th ed.), pre- and posttest scores provided on objective behavioral measures, sufficiently large sample sizes ($n > 15$), and data that permitted the calculation of effect sizes. Of the 2 studies that met all criteria, it was determined that effect sizes exceeded .6 between pretest and posttest objective measures of attention. Findings on measures of impulsivity and reaction time were inconclusive. One feature of EEG neurofeedback is that it provides real-time data on brain function and can be used as a noninvasive intervention to treat attention deficits and improve academic performance (Monastra et al., 1999). Studies consistently suggest that neurofeedback training enhances cognitive performance (Vernon et al., 2003), increases IQ (Linden, Habib, & Radojevic, 1996), and improves attention (Leins et al., 2007). Furthermore, positive changes in these domains remain robust in follow-up studies (Strehl et al., 2006). Most research examined in this analysis supports the contention that neurofeedback is an efficacious intervention, but given the limited number of fully controlled studies with adequate sample sizes, there remains a need for additional research.

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The Frontal Alpha Asymmetry During Luteal Phase and Follicle Phase in Premenstrual Dysphoric Disorder

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Introduction

This study presents the characterization of premenstrual dysphoric disorder (PMDD) as a premenstrual syndrome (PMS) disorder with extreme negative affectivity, such as a depressed mood. Resting frontal alpha asymmetry was a biomarker in this major depressive disorder. The purpose of the present study was to explore the frontal alpha asymmetry in an experimental task during the luteal phase and the follicle phase in PMDD and non-PMDD.

Method

This study recruited 10 PMDD college women (M age $= 20.40 \pm .97$) and 10 non-PMDD control women (M age $= 20.10 \pm 1.37$). There was no significant difference in age ($t = .57$, $p > .05$). The PMDD met the following criteria: Menstrual Discomfort Questionnaire (MDQ >70) and Beck Depression Inventory–II (>19); the non-PMDD included MDQ $\leqq$70 and BDI-II $\leqq$19. The frontal electroencephalogram (F3 / F4) of all participants was measured during the luteal phase and the follicle phase of the menstrual cycle in the following sequences: baseline measurement (3 min), recall of a depressive event guided by experimenter (5 min), recovery measurement (3 min), and relaxation measurement (3 min). The alpha asymmetry score (A2) was computed by subtracting left alpha amplitude from the right alpha amplitude [$A2 = (R - L)/(R + L)$].

Results

There were significant differences in the A2 score between PMDD and non-PMDD during the luteal phase ($t = -2.253$, $p < .05$) but not in the follicle phase ($t = -1.254$, $p > .05$). The three-way analysis of variance showed there was no interaction effect ($F = 1.62$, $p > .05$), but there was significantly group differences between PMDD and non-PMDD ($d = 0.33$, $p < .05$). The participants with PMDD tended to have alpha asymmetry during the depressive recall situation. However, the frontal alpha asymmetry was not found in non-PMDD.

Conclusions

The present study supports the frontal alpha asymmetry during the depressive recall situation in the luteal phase for PMDD but not in the follicle phase. The results of this study can apply the alpha training of neurofeedback in the luteal phase for PMDD.

Results of a Survey of Practices by U.S. Neurofeedback Practitioners

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Introduction

As approximately 33% of children with attention deficit hyperactivity disorder (ADHD) fail to benefit fully from the established treatments of medicine and behavior modification (MTA Cooperative Group; Swanson et al., 2001) and an unknown proportion refuse the most effective treatment (medication), additional complimentary or alternative treatments (CATs) are greatly needed. Recently, there has been considerable academic and consumer interest in youth CATs shown by a dramatic increase in Medline published randomized controlled trials (Chan, 2008), 11.8% of U.S. youth utilizing CATs annually (Barnes, Bloom, & Nahin, 2008), annual (1996) expenditures of $127 million on pediatric CAM visits and $22 million on remedies (Yussman, Ryan, Auinger, & Weitzman, 2004), 12 to 68% use in pediatric ADHD (Sinha & Efron, 2005), 93% of pediatricians reporting patients with ADHD asking about, and 38% patients using CATs. One such CAT is neurofeedback (NF; Kamiya, 1968), which has been used to treat several psychiatric problems, particularly child and adolescent ADHD (Hirshberg, Chiu, & Frazier, 2005). Research on the NF treatment of youth with ADHD has recently dramatically increased in quantity and improved in quality (Lofthouse, Arnold, Hersch, Hurt, & deBeus, in press).

Alongside these developments are indications that the marketing of NF has intensified and parents of youth with ADHD are increasingly seeking out NF for their children. Despite these changes, unlike the aforementioned research on CATs in general, there is no information on patterns of NF usage or treatment practices of practitioners who routinely treat, usually without insurance coverage, youth with ADHD. With this study we aim to identify specific practice patterns of U.S. practitioners who use NF to treat youth with ADHD. Identifying such practice patterns offers great benefits for NF practitioners, consumers, related professional associations and future research grant applications.

Method

On May 1, 2011, an Ohio State University Institutional Review Board–approved online survey of treatment practices associated with the NF treatment of youth with ADHD will be sent to a sample of U.S. NF practitioners. The sample will be composed of members of the top two U.S. NF practice/research organizations and certificants who have agreed to participate in this study: the International Society for Neurofeedback & Research (ISNR), Association for Applied Psychophysiology and Biofeedback (AAPB), and Biofeedback Certification International Alliance (BCIA). Only members who treat youth (i.e., $\leq$18 years old) with NF in the United States will be asked to participate. ISNR estimates that will include 640 of its members, AAPB 134, and BCIA 500 certificants, for a total of 1274 potential participants. The survey's 40 questions were developed via consultations with the ISNR, AAPB, BCIA, and several top researchers in the field of NF.

Results and Discussion

Data collection will run from May 1 through May 31, 2011. In June, data will be downloaded, analyzed by basic descriptive statistics to identify response patterns and ready for presentation at the ISNR conference in September. Results will be presented on practitioners' general background (i.e., location [U.S. state], type of practice, training, certification/license, professional title, and years of training), assessment/treatment outcome practices, clinical samples, and NF practices (i.e., approach, technology, effect/adverse effects, insurance coverage). To examine the representative nature of this sample, we intend to calculate a percentage response rate (number of association members who treat pediatric ADHD/number of respondents) to quantify the representative nature (in terms of a percentage of the entire population) of our sample. The interpretation and implications of all these results will also be discussed.

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Binaural Beats Alter Lateralized Attention

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Introduction

Little evidence exists that binaural beat entrainment can alter attention and behavioral performance. The anecdotal reports and few experimental studies that do exist tend to reach conflicting conclusions. We conducted a randomized controlled study with two different types of binaural beats to investigate their effects on attention.

Methods

Eight participants were exposed to different binaural beat protocols (beta and theta) on 2 separate days. Pairing entrainment sessions allowed participants to act as their own control for possible entrainment effects. Protocol order was counterbalanced across participants to control for order effects. A 64-channel EEG was recorded before, during, and after the presentation of binaural beats. The Lateralized Network Attention Test was also administered during the presentation of binaural beats, to measure changes in covert orienting of spatial attention in each hemisphere.

Results

There were significantly different effects of the 2 binaural beat types on conflict resolution and spatial orienting in the 2 hemispheres. EEG analysis is expected to reveal differences in individual subject spectral measures before and after entrainment sessions.

A Book Finally Written: Case Study of Effective Intervention Five Years Post Closed Head Injury

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Introduction

This case study concerns a 42-year-old woman (JS) who suffered a closed head injury in a car accident in 2000. This client received all the best medical and rehabilitation care, but she was still unable to function at work or within her social setting. The goal of this presentation is to demonstrate how this client was able to regain full functioning after 84 sessions that combined neurofeedback (NFB), biofeedback (BFB), and learning strategies. JS came to the ADD Centre in August 2005 and started her program in September 2005 for NFB and BFB treatment. Previously she had treatment through the Toronto Rehab Institute and made improvements on most of her functions, but she continued to have difficulties with reading, writing, cognitive processing, and attention. The loss of writing was particularly devastating for the client because she was a writer before the accident. In addition, she had trouble with listening, and her emotional response was flattened. She had lost her sense of humor and would know something was supposed to be funny but not quite get it. She often needed people to speak more slowly so that she would be able to process the information communicated to her. She presented with traits much like those of a client with Asperger's syndrome combined with ADHD, learning disabilities, and anxiety disorder. She communicated in a monotone and very matter-of-fact manner. While doing her NFB and BFB from September 2005 until August 2007, her speech and communication skills as well as the emotional tone in her voice improved. These improvements were substantial to the extent that she wrote and published a book that she had started prior to her brain injury. Another major improvement was her ability to read again, as prior to her accident she was an avid reader. She currently is working on another novel.

Method

Over a period of 2 years, this client had 84 NFB combined with BFB training sessions. The

instrument used was the Biograph Infiniti from Thought Technology, and the screens were from the Thompson Setting-up-for-Clinical Success suite, which allows NFB and BFB to be monitored at the same time. Biofeedback included skin conduction and heart rate variability (HRV). Each of the treatment sessions lasted 50 min. The training parameters were set by Dr. Thompson after analysis of the 19-channel EEG recording. Such analysis was carried out using NeuroGuide (NG) and LORETA. Sites and frequencies were selected based on the correlation of her symptoms, and the findings of her QEEG compared with the normative database from NG. Examples will be shown in the presentation. The biofeedback parameters were decided upon after a psychophysiological stress assessment.

Results

This patient made significant gains as measured on objective testing. The Integrated Visual and Auditory Continuous Performance Test (IVA), hyperactivity went from extreme to none; IVA Full Scale–Response Control Quotient went from 93 pretraining to 116 posttraining (more than 1 standard deviation), and auditory and visual response control standard score went from 93 and 95 pretraining to 108 and 119 posttraining, respectively. Her Full Scale Attention Quotient (FAQ) was more than 3 standard deviations below the mean pretraining and went from 50 on the FAQ to 111. Auditory and visual attention quotient went from 47 and 64 pretraining to 100 and 119 posttraining, respectively. On all the standard scores, she showed gradual improvements over time. Wechsler Adult Intelligence Scale (WAIS) prior to coming to the ADD Centre but after the accident (in 2003) were verbal 73rd percentile and performance 95th percentile. In 2007, after 80 sessions training, the WAIS–IV was readministered, and her verbal score was improved to the 99.5th percentile, and her performance score was also at the 99th percentile. These updated scores were likely a return to her preaccident baseline, as she had been a very high-functioning individual. Her training had included a combination of NFB + BFB + learning strategies. In all sessions, the patient had HRV feedback. With 50-min sessions she had single-channel EEG referential feedback. Her training was at F8, CPz, and F3, always referenced to the left ear. At F8, 3–7 Hz was decreased and 13–15 Hz increased while she was doing visual games. CPz-left ear reference, training was carried out to decrease 3–9 Hz and 23–35 Hz, and increase 11–12 Hz. At F3, while doing verbal/reading cognitive tasks, she was trained to decrease 3–7 Hz and increase 15–18 Hz. This was followed by continuing HRV and Skin Conductance (SC) training. Between baseline and post 80 sessions, assessments demonstrated using Dr. Lubar's A620 (Autogenics) assessment program, a decrease in theta, 3–7 Hz from 13.21 to 11.98 μv, increase in beta, 15–18 Hz from 4.40 to 6.11 μv (this program does not measure high-frequency beta). In our centre, pre- and post-μv ratios at Cz are calculated at baseline and post 40, 60, and 80 sessions for (4–8/16–20), (3–7/15–18). These ratios decreased from 2.16 to 1.61 and 2.45 to 2.05, respectively. Baseline picawatt $(4 \text{ to } 8 \text{ Hz})^2$ / $(13 \text{ to } 21 \text{ Hz})^2$ (Monastra et al., 1999) ratio decreased from 2.05 to 1.15. In the 19-channel EEG assessments, Dr. Thatcher's NG Learning Disability Discriminant Analysis post 40 to post 80 sessions, her NG, LD Probability Index changed from an 85.0% probability of having a learning disability to zero probability. This corresponded to this client demonstrating a continuous and marked improvement in learning ability. After amplitude training was done, remaining coherence problems were addressed. She was trained to increase theta coherence F8–FZ. Theta hypo-coherence F4–F8 decreased from −2.12 to +0.31. Although initially she had difficulty with metaphors and her voice was very monotone, as coherence improved in the right frontal area, her vocal tone normalized completely and she was fully capable of understanding metaphors.

Conclusion

As can be observed from this case study, the combination of NFB with BFB and learning strategies is an effective intervention for individuals

with closed head injury. I hope that the results from this case study will encourage further research into combining NFB with BFB and cognitive strategies as a viable treatment for clients even several years after the injury.

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Where Fear, Risk, Thrill, and Performance Mastery Meet: Action Sport Athlete Brain States

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Action sport athletes spend a lifetime pursuing performance mastery in extremely high-risk environments. Mistakes often are closely linked with risk of injury. Although more traditional ''stick and ball'' sport development creates opportunities to ''learn'' in a relatively safe environment, the action sport athlete is not permitted such luxury. In addition, the path to become an action sport athlete is not clearly defined. The action athlete has very few options to join sport teams, join developmental programs, or receive explicit and continual skill instruction. They are often required to develop their technical, physical, and mental skills in a self-determined, high-risk manner. To become a world-class action sport athlete, it is reasonable to assert that the psychological, emotional, physical, environmental, and possibly genetic factors are different for them than for their traditional sport athlete counterparts. The search for performance mastery in a highly charged, high-risk environment fundamentally would require a different set of performance mental capabilities and characteristics. To test these theoretical differences, a pilot analysis of quantitative electroencephalography measurements (scalp electrode analysis and eLORETA) of 10 professional action sport athletes were compared to a control group of professional athletes in the sports of baseball, basketball, golf, running, and tennis. The control group of professional players was chosen because they are similar in the time commitment, training, and high-performance demands but have a lower incidence of previous mild traumatic brain injury than other nonaction professional sports (e.g., soccer, North American football, hockey, etc).

Event-Related Potential Study of Attention Regulation in ADHD, Autism Spectrum Disorder, and Typical Children

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Introduction

Autism spectrum disorders (ASD) and attention deficit/hyperactivity disorder (ADHD) are very common developmental disorders that share some similar symptoms of social, emotional, and attention deficits. This study is aimed to help understand the differences and similarities of these deficits using analysis of dense array event-related potentials (ERP) during Kanizsa illusory figure (Kanizsa, 1976) recognition task. Although ADHD and ASD seem very distinct, they have been shown to share some similarities in their symptoms. According to diagnostic criteria enunciated in the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text rev. [*DSM–IV–TR*]; American Psychiatric Association, 2000) both ASD and ADHD are mutually exclusionary diagnoses. There is a growing consensus from clinicians, however, that behavioral characteristics of ADHD are observed in 14 to 78% of ASD patients (Holtman, Bolte, & Poustka, 2007; Keen & Ward, 2004; Lee &

Ousley, 2006; Leyfer et al, 2006; Reiersen, Constantino, Volk, & Todd, 2007; Ruggieri, 2006; Sinzig et al., 2009; Yoshida & Uchiyama, 2004). These studies question the validity of comorbidity as an exclusionary criterion within current *DSM–IV–TR* guidelines and argue in favor of its revision for the upcoming *DSM–V* (Ruggieri, 2006). Although behavioral characteristics of autism and ADHD may coexist, the more poignant question is whether both conditions share the same underlying pathophysiology. Without the presence of biomarkers, diagnosis based on observed behaviors is fraught with difficulties. The aim of this study involved comparing the ERP profiles of ADHD, ASD, and typical control subjects in a shape recognition task to investigate effectiveness of differentiation of target and nontarget stimuli. Our hypothesis was that children with ASD will show less pronounced differences in ERP response to target and nontarget stimuli as compared to typical children and children with ADHD. The latter group was predicted to have less reactivity to nontarget cues. We expected to find other ERP manifestations of attention regulation and other executive function differences between ASD and ADHD.

Methods

Participants with ASD ($N = 16$) and ADHD ($N = 16$) were referred by the Department of Pediatrics. Typical children ($N = 16$) were recruited through advertisements in the local media and schools. There was no significant difference in age ($M = 13.6$ years, $SD = 2.5$), gender, or IQ between the 3 groups. EEG was collected using 128-channel EGI EEG system. The task involves the recognition of a specific illusory shape—in this case, a square or triangle—created by 3 or 4 inducer disks. Subjects were instructed to press button only in response to an illusory square figure.

Results

There were no between-group differences in reaction time (RT) to target stimuli, but both ASD and ADHD committed more errors; specifically, the ASD group had statistically higher commission error rate than controls. Posterror RT in this group was exhibited in a posterror speeding rather than corrective RT slowing typical for the controls. The ASD group also demonstrated an attenuated error-related negativity as compared to ADHD and controls. The fronto-central P200, N200, and P300 were enhanced and less differentiated in response to target and nontarget figures in the ASD group. The same ERP components were featured by more prolonged latencies in the ADHD group as compared to both ASD and typical controls.

Conclusions

Our results show significant differences both in behavioral and electrocortical responses between ASD, ADHD, and typical controls during performance on illusory figure test. The findings are interpreted according to the ''minicolumnar'' hypothesis proposing existence of neuropathological differences in ASD and ADHD, in particular, minicolumnar number/width morphometry spectrum differences. In autism, a model of local hyperconnectivity and long-range hypoconnectivity explains many of the behavioral and cognitive deficits present in the condition, whereas the inverse arrangement of local hypoconnectivity and long-range hyperconnectivity in ADHD explains some deficits typical for this disorder (Casanova et al., 2009; Williams & Casanova, 2010). Current ERP study supports the proposed suggestion that some between group differences (ASD vs. ADHD) could be manifested in the frontal ERP indices of executive functions during performance on illusory figure categorization task.

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Neuromodulation Using rTMS Improves Error Monitoring and Correction Function in Autism Spectrum Disorders

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Introduction

One important executive function known to be compromised in autism spectrum disorders (ASD) is related to response error monitoring and posterror response correction. Current theory and research suggests that these prefrontal deficits may contribute to social-emotional and social-cognitive impairments in autism (Henderson et al., 2006). Several reports (Bogte, Flamma, van der Meere, & van Engeland, 2007; Sokhadze, Baruth, Tasman, et al., 2010; Thakkar et al., 2008; Vlamings, Jonkman, Hoeksma, van Engeland, & Kemner, 2008) indicate that children with ASD show reduced error processing and deficient behavioral correction after an error is committed. This finding could be explained as a reflection of ASD patients' decreased sensitivity to behavioral errors or a reduction in behavior correction ability. Error sensitivity can be readily examined by measuring event-related potential (ERP) components associated with responses to errors: the fronto-central error-related negativity (ERN) and the error-related positivity (Pe). The ERN is a response locked negative ERP deflection, emerging between 40 ms and 150 ms after the onset of a commission error. Usually, this ERN is followed by a positive wave referred to as the Pe potential. It is suggested that the ERN reflects an initial automatic brain response as a result of an error, and the Pe indicates the conscious reflection and comprehension of the error (Overbeek, Nieuwenhuis, & Ridderinkhof, 2005). ERN and Pe are generally accepted as neural indices of response

monitoring processes in psychophysiological research and clinical neurophysiology. The goal of our study was to investigate whether behavioral response error rate, posterror RT change, ERN, and Pe will show positive changes following 12-week-long slow frequency repetitive TMS (rTMS) in group of high-functioning children with ASD. Considering that in our prior studies we showed reduction in error rate in ASD group post 6 sessions of the left dorsolateral prefrontal cortex (DLPFC) rTMS, we hypothesized that 12 sessions of rTMS bilaterally applied over the DLPFC will result in improvements reflected in RT, ERN, and Pe measures.

Methods

High-functioning participants with ASD ($N = 30$) were referred by the Wisskopf Child Evaluation Center. Diagnosis was made according to the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text rev.; American Psychiatric Association, 2000) and further ascertained with ADI-R (Le Couteur, Lord, & Rutter, 2003). Then participants were randomly assigned to either active rTMS treatment ($N = 15$) or waitlist (WTL) groups. There were no significant differences in age ($M = 13.5 \pm 2.6$ years), gender, or IQ between groups. Baseline and post-TMS/or WTL EEG was collected using 128-channel EEG system. The task involved the recognition of a specific illusory shape—in this case, a square or triangle—created by 3 or 4 inducer disks. Subjects were instructed to press the button only in response to an illusory square figure. Treatment group received 12 weekly 1 Hz rTMS sessions (150 pulses, 90% of motor threshold), whereas the WTL subjects were tested twice after an 8- to 12-week waiting period.

Results

There were between-group differences neither in reaction time (RT) to target stimuli nor in rate of commission and omission errors. ERN in TMS treatment group became significantly more negative (by $4.99 \pm 4.35\,\mu V$, $F = 5.07$, $p = .03$), whereas Pe increased (from 5.96 ± 5.02 to $9.72 \pm 5.28\,\mu V$, $F = 5.55$, $p = .019$). No latency differences were detected. The number of omission errors decreased ($t = 2.26$, $p = .034$). The RT did not change, but posterior RT became slower (from -22.3 ms to 10.6 ms post-TMS). There were no changes in RT, error rate, post-error RT slowing, or ERN/Pe measures in the WTL group.

Conclusions

Our results show significant post-TMS differences in the response-locked ERP such as ERN and Pe, as well as behavioral response monitoring measures (omission errors, posterror slowing) indicative of improved error monitoring and correction function. This executive function is important for ability to correctly evaluate committed error and adjust behavior to prevent from rigid and repetitive actions. Elucidating the neurobiological basis and clinical significance of response monitoring and correction deficits in ASD represents a promising direction for further quantitative EEG-based research. The ERN and Pe along with behavioral performance measures can be used as functional outcome measures to assess the effectiveness of neurotherapy (e.g., rTMS or neurofeedback) in children with ASD and thus may have important practical implications.

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Neural Networks: An Exploration of Functions Influenced by Neurofeedback

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This talk will give a brief overview of neural networks, with an emphasis on neural connectivity loops that underlie these networks. The underlying loop that goes cortex to basal ganglia to thalamus and back to functionally related areas of the cortex is central to the discussion. There will also be an explication of the relationship between common symptom pictures and how those difficulties relate to dysfunction in various networks. The origins of this presentation go back to 1995 at one of the early meetings of the newly formed Society for Neuronal Regulation where we presented a paper titled ''Exceptional Results with Exceptional Children.'' The cases presented were children with severe behavioral disorders who had not responded to traditional treatments such as medications, behavior modification, and extensive psychotherapy. With parental consent we had tried a new, purely experimental approach for which there was little research support. The parents were desperate and hopeful, even though we were honest about having no way of explaining why neurofeedback (NFB) might work, except to cite outcomes of increased attention span in children with ADD who were treated using NFB.

Despite our limited knowledge and equipment that only did single-channel EEG recordings and basic biofeedback (BFB; Autogenics A620 and Focused Technologies F1000), the cases we worked with made remarkable improvements regarding both behavior and being weaned off medications. A dramatic example was a 13-year-old boy with autism who initially just screeched and flailed his arms when seated in front of the computer. By the time he finished 85 sessions he had been demitted from the MID class (for children with mental retardation) and had moved on to high school, where he was enrolled in regular classes except for mathematics, in which he took an advance class. In addition, he was being invited by his peer group to parties. Eight years later when we called to invite him back for follow-up his father declined, explaining that his son was doing well in college and did not want anyone to know that anything had ever been wrong with him.

We reviewed our early work with the goal of better understanding what might have been the underlying mechanisms that produced these rather unexpected, positive results. We had done single-channel assessments and training, placing the active electrode over Cz, referenced to the left ear in most cases or, in some cases (especially when electromyogram artifact was a problem), we had used a sequential placement: FCz and PCz. Both referential and sequential training were successful with very difficult cases.

With today's perspective and the knowledge gleaned from 16 additional years in the field, we suggest that a possible explanation of the good results might be based on a theoretical framework that derives from both other people's research and our own evidence-based practice.

Quantitative EEG (qEEG) data (either single channel or 19 channel) continues to provide the basis for planning all interventions. The 19-channel data, when available, are combined with LORETA analysis for source localization and then we apply knowledge of Brodmann Areas, functional networks, and the client's symptoms. Our observation is that there are both symptoms in common, and functional neural networks in common, among many of the disorders we worked with, both then and now.

In addition, many of the disorders we successfully treated using NFB + BFB may have had underlying mechanisms in common. For the most part, there appears to be dysfunction, to different degrees, in only a few basic networks. Many of the disorders, for example, have in common difficulties in attention (executive network) and/or anxiety (affect network). The autistic spectrum disorders (ASDs) have major difficulties in at least three major networks: executive, affect, and default. The majority of our patients, regardless of diagnosis, appear to have difficulties related to these networks with just a different ''balance'' of involvement across clients and diagnostic categories. These three networks can be influenced by neurofeedback at various sites over the central midline structures (CMS). They are also altered by means of biofeedback and, in particular, by heart rate variability (HRV) training, which will influence the same CMSs through afferents to the brain stem medulla and from these nuclei to the basal ganglia and the cortex. For all of the NFB training, neural loops exist that involve connections from cortex–basal ganglia–thalamus to cortex. These may affect many functionally related areas of the cortex. This will be discussed in terms of how we now think that our results with these early clients were achieved.

We were initially doing feedback, for the most part, over the CMS, but we will note that there are a number of exceptions to using CMS feedback as a starting point. We do not, for example, begin our training over CMSs if the main problem is a reading disorder or a seizure disorder. With dyslexia we usually follow the QEEG, which typically shows inactivity over Wernicke's area near the angular gyrus in the dominant hemisphere. With seizure disorders we may alternate sensorimotor response enhancement at C3 and C4 while decreasing slow wave near the focus of the epileptiform activity. Traumatic brain injury is another clear exception, and there are others. Nevertheless, beginning training over the CMSs is a reasonable starting point with many of our patients due to the network properties of the structures that underlie the CMS midline sites.

We will note that we have always combined NFB and BFB, and this talk will briefly explain how a CMS, the Anterior Cingulate (AC), connects with the medial and orbital prefrontal cortex and the entire limbic system. In addition, it receives input from the brain stem, which, important for our work, includes output from vagal afferents from the heart to the nucleus solitarus in the medulla, which connects to the locus coeruleus (noradrenaline production) and then to the limbic system including the AC. The AC has direct links to the hypothalamic-pituitary-adrenal axis. The audience should immediately see the role of these connections in the human stress response and the importance for treatment that combines HRV training with NFB to control stress. We will briefly describe how this relates to the distress network and supports our decision then and now to almost always combine NFB with BFB.

Treatment Analysis of SMR-Theta Neurofeedback Session Data After Control for EMG: Changes in Power and Ratios

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Introduction

In everyday practice of neurofeedback (NF), treatment evaluation often is focused on questionnaires or self-reports. However, electroencephalography (EEG) parameters (e.g., amplitudes and ratios) within and over sessions also are valuable measures for treatment effect. Often these 2 approaches do not concur. Treatment evaluation research often addresses

questionnaires only. If EEG is involved it mostly concerns pre- and posttreatment QEEG only. There is considerable debate whether one is able to see any changes after treatment, and as such it questions the processes due to NF, if any. This study investigates the trends in EEG data within and over sessions of 24 patients treated with either a discrete or continuous SMR/theta feedback protocol for ADHD. The research questions are, (a) Which changes can be found in the designated bandwidth areas of these protocols? (b) What are the differences between these two protocols? (c) What factors affect EEG parameters? Primary outcome measures are absolute and relative power/percentage power of SMR and theta, standard deviations, and the SMR/theta power ratio. Secondary outcome measures are associations with time of day, electromyogram (EMG) power, duration of training trial, type of feedback, time between sessions and seasonal effects.

Method

All session data will be reviewed for EMG and any other artifacts. Trend analyses will be used to plot any learning curves.

Results

Results are to be provided at the conference.

Discussion

The results have major implications for everyday practice. If no changes are found, and no associations with the secondary outcome measures, the use of EEG power in order to monitor change processes becomes questionable. The study design does not allow for the assessment of placebo effects, but this suggestion may then gain support. For research purposes FMRI validation of the training effects may then be an option for further insight into the processes involved in neurofeedback.

QEEG Guided Neurofeedback to Treat Schizophrenia: A Case Study

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The subject of this case study was a 21-year-old male college student diagnosed with adult onset schizophrenia, undifferentiated type. Due to the advancement of this disorder he was unable to complete mandatory coursework and forced to take a leave of absence prior to his senior year at the University of Southern California. He was given a very poor prognosis by his psychiatrist and placed on aripiprazole (Abilify) with the dosage varying between 5 mg and 20 mg.

His neurofeedback therapy was directed mainly by the results of 5 serial quantitative EEGs (QEEGs) administered over an 18-month period. With each QEEG new areas of statistically significant hypocoherence were targeted for treatment. The subject engaged in intensive neurofeedback having four to six 30-min sessions per week totaling 530 in-office sessions utilizing EEG Spectrum's EEGer software (amplitude, sum, and coherence modules). The subject engaged in no other therapy or interventions.

Initially neurofeedback therapy was conducted predominantly at C3 and C4 (according to the International 10–20 System) with the goal being to obtain cortical stabilization. This phase of treatment lasted for 66 sessions. In the second phase of neurofeedback, the subject was given 287 sessions intended specifically to remediate statistically significant QEEG derived coherence abnormalities. Interspersed throughout this second phase of treatment were 117 sessions of cortical stabilization. Stabilization was done before and after each QEEG was administered as well as when clinically indicated.

Neurofeedback therapy involves application of certain protocols that determines proper electrode placement and identifies which frequencies or coherence pairs are trained. In both phases of training, the reward provided the subject positive feedback (visual and auditory) when identified criteria were met. Degree of cortical stabilization was determined by the subject successfully reaching previously attained optimal levels of amplitude readings in critical frequency ranges as well an ability to maintain low coefficients of variation.

Coherence reward was provided when immediate computer analysis indicated that the areas identified showed improved coherence readings. The choice of protocol was optimized based upon either abnormal frequency characteristics or statistically significant Z-Scored FFT hypocoherence abnormalities identified by NeuroGuide. Convergence between QEEG abnormal findings with neurophysiological correlates of functional impairments were the main factors considered in determining the treatment plan. The number of sessions trained for each coherence abnormality was estimated using a calibrated multiplier positively correlated with standard deviation abnormalities. The main factors used to determine the point of maximum benefit for any hypocoherent pair identified for training were improved functional capacity and real-time percentage coherent data provided by the EEGer software.

Over the course of this subject's neurofeedback, the QEEG identified 36 coherence abnormalities. Results of neurofeedback therapy and subsequent QEEG analysis showed that the neurofeedback was effective at normalizing previously abnormal coherence readings with the exception of 2, which then normalized after being treated a second time. In spite of the fact that targeted coherence abnormalities normalized, with each new QEEG there appeared new coherence abnormalities presumably caused by the encroaching schizophrenia.

During the time we were identifying and intensely treating QEEG-identified coherence abnormalities, the subject experienced a significant reduction in symptoms and a reduced need for aripiprazole (20 mg was reduced to 7.5 mg). This window of improved functioning allowed him to return to school, where he successfully completed his senior year in spite of a challenging course load and ultimately graduated from USC. Unfortunately, against the advice of his doctors and his family, the subject discontinued neurofeedback treatment. Within 6 months after stopping neurofeedback therapy and in spite of increased pharmacological intervention, the subject became markedly psychotic exhibiting delusions of grandeur, hearing voices, and paranoid ideation.

Adult onset schizophrenia beginning at the age of this subject typically has a very poor prognosis. However, for this subject, neurofeedback treatment was a powerful intervention enabling him to reach a difficult scholastic milestone on reduced levels of medication. This case study indicates that further research is warranted given the profoundly positive effect demonstrated by the neurofeedback intervention.

Enhanced EEG Coherence During Bilateral Eye Movements While Recalling an Unpleasant Memory: Implications for EMDR

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A number of therapeutic techniques to relieve traumatic stress have been developed in the past decades. One of the most frequently used clinical therapies is Eye Movement Desensitization and Reprocessing (EMDR), which uses bilateral eye movements to facilitate a reduction in the vividness of memories and associated affect. Although this technique has an extensive research history, EMDR has been challenged because the underlying mechanisms are not fully understood. A particular target of this criticism has been the role of and mechanisms underlying the bilateral eye movement component of EMDR. The goal of this study was to examine the bilateral eye movements used in EMDR therapy and to test an interhemispheric integration model for EMDR by exploring EEG coherence. Participants were not diagnosed with posttraumatic stress disorder (PTSD), but they did recall a moderately unpleasant event during the bilateral eye movement process. The procedure followed previous research using moderately unpleasant memory recall to approximate

PTSD characteristics. The bilateral eye movement procedure also followed the EMDR protocol and conditions from a previous study examining bilateral eye movements and EEG coherence.

A sample of 55 undergraduate and graduate women was used in this study. Each participant experienced a 5-min eyes-opened baseline condition followed by 1 of 3 treatment conditions: (a) an eye fixation condition, (b) an eye fixation with background bilateral light movement condition, and (c) a bilateral eye movement condition. During the treatment condition, the participant recalled a moderately unpleasant episodic memory. Each of 5 eyes-opened treatment conditions lasted for 1 min, followed by an eyes-opened 1-min EEG recording period, for a total of 5 min of EEG recordings. EEG data were noise artifacted, power spectral analyzed, and statistically analyzed for interhemispheric coherence differences between conditions for clusters of frontal pole (Fp), frontal, central, parietal, and occipital electrodes.

An analysis of covariance, with baseline values as the covariate, was used to compare EEG coherence values following the 3 treatment conditions. The results revealed significantly higher EEG coherence for Beta and Gamma frequencies in the frontal region following bilateral eye movements compared to the other 2 conditions. LORETA virtual magnetic resonance imaging neuroimages of these effects are presented.

These results supported the hypothesis of increased interhemispheric coherence following bilateral eyes movements during recall of an unpleasant memory, consistent with the hypothesized effects of EMDR. Furthermore, these effects were found in frontal brain regions involved in planning, reasoning, decision making, and verbal episodic memory retrieval, also consistent with the interhemispheric integration model. The lack of significantly increased signal coherence at the Fp region and the removal of eye movement artifacts prior to data analysis reduce the likelihood of this obtained effect being a result of eye movement artifacts.