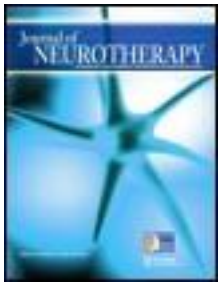

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Abstracts

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ABSTRACTS

Task Related Slowing: Deactivation, or Cognitive Processing Deviation?

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Introduction

Rhythmic slow wave 4-8 Hz (theta) EEG activity has traditionally been considered as a correlate of drowsiness or attention deficit disorder (Makeig, Bell, Jung, & Sejnowski, 1996; Lubar & Lubar, 1999), and rhythmic very slow wave 0.5-4.0 (delta) EEG activity has been considered as a sign of either deep sleep or brain pathology (Niedermeyer, 1999). However, several recent studies have associated slow-wave brain activity with working memory and stimulus detection functions. For example, Klimesch and colleagues have suggested that 4-8 Hz activity is correlated to working memory functions and may manifest cyclic reciprocal communication between the cortex and the hippocampus (Klimesch, 1998). Schuerman and colleagues relate the "delta" component (0.5-3.5 Hz) of the P300 ERP to decision making and matching during cognitive tasks like detection of auditory stimuli close to the hearing threshold (Schuerman, Basar-Eroglu, Kolev, & Basar, 2001).

One of the goals of this study was to determine if slow wave EEG reflects only brain deactivation during reading. If so, areas responsible for the different reading modalities should show decreased amplitude of slow-wave EEG during reading when compared to a resting baseline. If, on the other hand, slow wave EEG during reading reflects cognitive processing, then brain areas involved should show increases in slow wave amplitude. Another purpose of the present study was to explore the potential of slow wave QEEG to identify topographically differential cortical activity during different reading tasks that selectively engage the visual, phonetic, and semantic modalities of reading. It was hypothesized that different processing modalities may manifest as EEG activity at relevant cortical areas.

Methods

The present study explored the slow wave EEG amplitude differences between resting and reading states in a group of 19 non-clinical young adults (12 male, 7 female). EEG was recorded during an eyes-open resting baseline, and three different reading tasks selectively engaging the visual, phonetic, and semantic reading modalities.

EEG was recorded with a Lexicor NeuroSearch-24 analog to digital system, and all data were stored and visually artifact rejected using a Pentium 120 MHz computer, and Lexicor's v41e software. Nineteen-channel electrode caps using the 10/20 international electrode placement system by Electro Cap Inc. were used, with linked ear lobe references. The EEG data were collected with a band-pass filter set at 0.5-32 Hz for 128 samples per second recordings and at 2-64 Hz for 256 samples per second recordings. Fast-Fourier Transformation (FFT) processed digital EEG with cosine tapering (Hanning window). Frequency spectra between 0.5 and 8.0 Hz were analyzed in two frequency bands, 0.5-4.0 Hz (delta) and 4.0-8.0 Hz (theta).

Results

Multiple t-test analyses comparing the three reading tasks with the baseline showed significant amplitude increases during reading mostly in the 0.5-4.0 Hz and some in the 4.0-8.0 Hz band. These changes were topographically different among the three reading tasks. During visual reading, amplitude increased at C3, C4, T3, T4, and T5 for the 0.5-4.0 Hz band, and at T5 and T6 for the 4-8 Hz band. During phonetic reading, amplitude increased at T3, T4, F3 and F7 for the 0.5-4.0 Hz band, and at T5 and FP1 for the 4-8 Hz band. During semantic reading, amplitude increased at T3, T4, C3, C4, F3, F7, F8, CZ and FZ for the 0.5-4.0 Hz band and at T5 for the 4-8 Hz band.

Conclusions

The present data support previous studies that relate amplitude increases in slow wave EEG with cognitive processing. This suggests that during reading tasks in awake, non-clinical young adults, increased amplitude in slow wave EEG may illustrate cognitive processing. We propose that slow frequency EEG is a form of brain activity, rather than inactivity. The form of slow wave EEG being different between pathology/sleep and healthy cognitive functions supports this conclusion. In

the first case (pathology/sleep), slow waves are dominant, rhythmic and of high amplitude. In the latter case (healthy cognitive functions), however, slow waves are non-dominant, arrhythmic and of low amplitude.

In summary, amplitude increases in slow-wave EEG are part of the normal reading process and it appears at scalp electrodes close to cortical areas expected to be involved according to different reading modalities. Implications for neurofeedback involve tentative models for cognitive processes.

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Premenstrual Dysphoric Disorder and Changes in Prefrontal Alpha Asymmetry

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Introduction

Premenstrual dysphoric disorder (PMDD) is characterized by symptoms of irritability, anger, internal tension, dysphoria and mood lability,

and in some women, suicidal ideation. It is often found in persons who have a major psychiatric disorder or medical condition. It is distinguished from premenstrual syndrome (PMS), a condition that affects many women with similar but less severe symptoms (Steiner & Born, 2000). Low plasma levels of gamma-aminobutyric acid (GABA) have been found in women with PMDD, but not in women diagnosed with PMS, during the late luteal phase of the menstrual cycle (Halbreich et al., 1996). A relationship between the onset of menses and brainwave changes in frontal alpha asymmetry has been observed in women diagnosed as having PMDD. Data on two monthly cycles for five women in neurofeedback treatment for depression are presented.

Method

Five women diagnosed with major depressive disorder, who also suffered from PMDD, have been treated with neurofeedback for depression using a patented protocol designed to increase alpha asymmetry in the right frontal cortex (Rosenfeld, 2000). The asymmetry score is defined as (F4-F3/F4+F3), where F4 is the alpha magnitude at the right frontal location, and F3 is the magnitude at the left frontal side, both referenced to CZ with an ear reference as ground. The EEG data was recorded on a Lexicor NeuroSearch-24 unit. Fast Fourier transforms (FFTs) were derived on Blackman-Harris windowed analog signals over one-second epochs (Harris, 1978). An index based on the percentage of time the alpha asymmetry (PTAA) score was greater than zero, was used as the criteria for training. Fifty-eight percent was used as the approximate cut off point for PTAA, which discriminates between the depressed and normal groups, with > 58% representing the non-depressed population (Baehr, Rosenfeld, Baehr, & Earnest, 1998). Four of the five women were seen twice a week; the fifth woman was seen three times a week.

Results

It had been noted that some women, who were otherwise successful in their asymmetry training, showed reversals in right frontal alpha asymmetry along with extreme symptoms of depression just prior to and during their menses. Restoration of normal scores and improvement in mood occurred at the end of menstruation. Medical solutions

have included increasing serotonin uptake inhibitors (SSRIs) during the luteal phase of the menstrual cycle.

Studies have shown that plasma GABA levels are lowered in patients with PMDD and may be related to depressive disorders (Halbreich et al., 1996). GABA is utilized by inhibitory neurons in the brain, which provide important input to the amygdala (Davidson, 2000). It is hypothesized that GABA deficiencies might result in an uninhibited amygdala, which if unchecked, may be related to the flood of negative thoughts and feelings that occur during this period of the menstrual cycle.

Conclusion

Monthly changes in right frontal alpha asymmetry have been observed in five women who were undergoing neurofeedback treatment for depression. These women have been diagnosed as having premenstrual dysphoric disorder that is characterized by extreme mood changes and lowered GABA levels. A hypothesis has been raised relating emotional lability to an uninhibited amygdala. Further research is needed to deepen our understanding of this disorder and to find appropriate treatment strategies in both the medical and psychological fields.

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Thinking Nonlinearly About Nonlinear Brain System Dynamics

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Introduction

When we consider brain structure/function interrelationships today, there remains an ingrained tendency toward scientific conceptualizing that is both reductionistic and linear. Such conceptualizing is characteristic of the analytical functions of the brain itself that tend to be localized in the left hemisphere in many individuals. The tendency to probe the brain down to ever-increasingly smaller scales and to assume that the knowledge obtained generalizes to higher levels of scale is very subtle and strong. While it is important to understand the molecular and cellular biology of neurons and glia, we must overcome the inertia of the long-held belief on the part of some sectors of the neuroscience community that more probing into the machinery of the neuron will unlock all the secrets of the brain.

Discussion

We are just beginning to appreciate the complex and nonlinear dynamical nature of the brain. A further shift in our "consciousness" about neural dynamics is needed in order to take the next steps in brain research. We need to be able to utilize in a more reflexive manner what we have already learned about the complex, nonlinear dynamical nature of the brain in order to "bootstrap" our own thinking processes about neural science itself. It is clear from developments in neural network theory in general that we must employ tools that enable us to understand how neurons interact with each other in small, intermediate, and large scale networks. At each of these levels different tools and strategies may be required. We need not only a bottom-up approach, but also a top-down one. Such tools must allow us to "see the forest for the trees" without at the same time blinding ourselves to the details of the neuronal apparatus.

Conclusions

We will present a few recent examples of this from the cognitive neuroscience literature. We will review briefly the concepts of nonlinear

dynamical systems (NDS) and complexity (C) of pertinence to this work. We will address the question "(How) can we embrace even further NDS and C in brain research?" and discuss models and applications of NDS and C in neuroimaging studies (including fMRI/EEG/MEG) from the author's own and other's research. A related question is "(How) can we use our whole brain (both left and right hemispheres) to better understand the whole brain?" We will also explore some potential lessons that may be drawn in this regard from energy/matter physics, and hope to offer some take-home ideas for your own research and clinical practices.

The Mean of the Median: A New Metric for Targeting in Clinical Neurofeedback?

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Introduction

In order to explore the role of "variability" around targets during Neurofeedback, NeuroCare Pro® software was used to measure the emergent median values of each of the targets employed during Period 3 training, as well as in post-hoc analysis of other data.

Methods

These median values were concurrently subjected to a 16 times per second averaging procedure to derive a dynamical measure of the variability of the emergent "central tendency" of each of the targets during clinical training. This "Mean of the Median" (or MoM) measure was used to derive the actual triggering of feedback events in reference to calculated divergence within a neighborhood around this dynamical measure. An 80 percent "inclusion" criterion was used for determining the size of the neighborhood for each target. For each inhibit target, feedback was produced and all feedback from all targets was enabled when the emergent median of the median remained within that neighborhood, whereas feedback for all targets was disabled by excursions beyond this neighborhood for any inhibit. The same basic procedure was used for augment targets except that excursions outside of an augment's neighborhood had no effect on any other target.

Findings

This procedure was used for active training of clients (N > 50), as well as for post-hoc analysis of pre-existing data obtained from other, successful Neurofeedback cases (N > 200) using different feedback paradigms, equipment and/or software.

Results and Discussion

Several interesting results have begun to emerge from these preliminary investigations:

1. Clinical improvements appear to be correlated with decrease in both negative and positive divergence for all inhibit targets. This reflects a kind of "regression to the mean" regarding inhibits during renormalization.
2. Renormalization of the inhibits may be an indicator of resilience in the CNS, or what Pribram refers to as efficiency.
3. Clinical improvements appear to also be correlated with a decrease in the number, duration and intensity of negative divergences for all augment targets but do not seem to be particularly correlated with any form of positive divergence for the same targets. Thus, it appears that it is not increases in augments per se that is important but lack of decreases.
4. Renormalization of the augments may be an indicator of flexibility in the CSN, or what Pribram refers to as effectiveness.
5. This procedure may yield some useful metrics for successful training regardless of the approach used.

AVS (Audio-Visual Stimulation) Effects in an Alzheimer's Patient as Documented by QEEG and LORETA

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Introduction

It is known that AVS can induce a frequency-following response in the EEG as measured on the scalp (Budzynski, Jordy, Budzynski, Tang,

& Claypole, 1999), but can AVS produce changes in the subcortical areas of the brain of an Alzheimer's patient? The new technique known as LORETA (Low Resolution Brain Electromagnetic Tomography) was used to determine deeper structure involvement and to compare that with QEEG results from the surface.

Method

A baseline QEEG (eyes open, eyes closed and serial sevens challenge) was followed by 20 minutes of AVS (a pseudorandom protocol with a frequency range of 9 to 22 Hz) during which a second eyes closed QEEG was taken. This was followed by a third QEEG right after stimulation and then a fourth after 15 minutes of rest following termination of the AVS. A final AVS was taken after the patient completed 30 sessions of daily use of the 20 minute AVS protocol over a six-week period.

Results

The analyses included QEEG spectral investigation as well as LORETA analysis. Considerable agreement was found between the QEEG spectral values and LORETA density values in deeper structures. For example, the QEEG spectral analysis showed the AVS stimulation decreased delta at T3 during stimulation and 15 minutes afterward and then after the 30-session training some 12 weeks later. The LORETA showed a decrease in delta in the left temporal, Brodmann Area 42 and in the superior temporal gyrus temporal lobe after the AVS and then after the 30-session training.

Conclusions

The AVS appears to produce improvement in the current density of various brain regions that are involved in Alzheimer's disease progression. The results appear as early as the first AVS stimulation period and last through the continuation of the 30-session training period with no or minimal decrease in results. The QEEG results generally agree with the LORETA but, of course, do not delineate the deeper structure condition. Hopefully further research will establish the generality and longevity of AVS treatment for this disorder.

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Nova Tech EEG, Inc. Knoxville, TN (provided the programs to generate LORETA figures and images).

Passive Infrared Hemoencephalography: A Three-Year Case Series

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Introduction

A discussion of the evolution of the technology, combined with a discussion of a three-year set of case studies, predominantly focused on treatment of migraine headaches.

Methods

As of the date of SNR 2001, Passive Infrared Hemoencephalography (pIR HEG) is now only three years old, and is still in its infancy. pIR HEG is a conceptual outgrowth of Hershel Toomim's Near Infrared Spectrophotometry Hemoencephalography (NIRS HEG, 1999) system. pIR HEG relies on thermal output from brain activity as the primary measure. In most cases, patient responses to the pIR HEG system appear to be similar to the responses seen with NIRS HEG, although there also appear to be some subtle differences, which need to be considered when comparing data.

Discussion

Both systems share a freedom from eye movement and muscle artifacts. All systems do have artifacts that do not represent real data. pIR HEG is no exception. Sources and characteristics of these artifacts will be discussed.

The reason HEG initially caught my interest was that 70 percent of my practice represents work with migraine patients. Although the pre-

cise etiology of migraine headaches has yet to be determined, there is universal agreement that the cerebrovascular system is intimately involved in the process (Bednarzcyk, Remier, Weikert, Nelson, & Reed, 1998; Moskowitz, 1998). Because of the vascular theories regarding migraine headaches, my original work using pIR HEG with migraines was directed at attempting to retrain the vascular system. This turned out to be unproductive. The process evolved into one that uses the pIR HEG signal to train increases in frontal brain activity as measured by increases in the pIR HEG signal. These increases appear to correlate with increased inhibitory functions that serve to act to prevent migraines and also to abort them in progress.

While migraines represent the main focus, tension type headaches, cluster headaches, medication rebound headaches and conversion headaches will also be discussed. Individual case studies will be presented. Supporting data will include infrared video images with and without headache activity. Summary data will be presented on response patterns using change in headache activity as the predominant dependant variable, with psychophysiological correlates as secondary dependant variables.

Conclusions

Passive Infrared Hemoencephalography is a very new process that is showing indications of being useful for working in the region of the prefrontal cortex. Improvements have been demonstrated in patients with migraine headaches, attention deficits, and other disorders related to excessive CNS activity.

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Intention and Consciousness in Neurofeedback

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Introduction

This talk will address the roles of intention and consciousness in the effectiveness of neurofeedback training, and the relationships between volitional and nonvolitional methods. The issue of conscious versus unconscious processing is essential, because some stimuli (including subliminal audio or visual) have an identifiable effect on the EEG regardless of the intent of the trainee, while others (conventional displays) must be perceived and interpreted consciously and with good intent for training to occur. Through what neurophysiological mechanisms do the intentions, beliefs, and motivations of a trainee affect the outcome of EEG training?

Methods

Published experimental results are reviewed, and considerations from neurophysiology and clinical experience are discussed in light of possible mechanisms. Experiments reveal that the perception of the intent to perform a voluntary action actually follows in time the irreversible brain processes that lead to that action. This sheds light on the role of intent in consciousness, and how intent is brought to bear in neurofeedback. Clinical experience also shows that motivation, belief, and reinforcing factors such as perception of improvement, positive feedback from family and school, and desire to change, affect the efficacy of neurofeedback.

Results

While conscious intent is an integral component in the learning process for neurofeedback, progress is contingent on elements of belief, predisposition, and willingness to learn. Nonvolitional methods can overcome some of these limitations by inducing change at a lower level, independent of the issues of willingness or desire. Such influences will not, however, result in the same type of learning as operant conditioning. There thus exists a tradeoff between rapid but less enduring noncontingent changes, and slower but more lasting, contingent changes, depending on the training regime that is employed.

Conclusions

A rationale for understanding and working with the issue of intent is presented. Differences exist between volitional and nonvolitional training methods. Hybrid systems that use multiple approaches are suggested, producing integrated feedback. These provide multi-pathway training, wherein diverse feedback loops may be exercised simultaneously. Conscious and unconscious processes can thus be combined, providing potential improvements in training efficacy.

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Logistic Regression Discriminant Functions for QEEG and LORETA

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Introduction

Neurofeedback treatments are designed to normalize abnormal quantitative electroencephalograph (QEEG) features. Typically, the patient's brain map is compared to a normative database in order to quantify the patient's deviance from normative values. Sometimes a clear diagnosis helps deciding the most appropriate protocol for the case. Combining the initial diagnosis with the database information offers the most reliable procedure to decide the most appropriate neurofeedback protocol. Discriminant functions are a tool to quantify the probability that the patient's QEEG features are typical of either one of two groups. One of the two groups is generally chosen to be normative, while the other is a homogeneous clinical group. Normative databases can detect deviation from normality, but cannot indicate if the QEEG pattern is commonly observed in a particular clinical condition. On the other hand, discriminant functions answer these kinds of questions. With the availability of software able to compute the maximum likelihood estimations,

logistic regression recently became a popular tool for the derivation of discriminant functions.

Method

Logistic regression is a generalized linear model in the LOGIT of a binary response. For our purposes, let the response be the membership in a normal group ("failure") or in a clinical group ("success"). Then, allow a set of QEEG or LORETA features to be the predictors of the response. This set will be a sub-set of all QEEG or LORETA features extracted. Given that the model holds, the set of QEEG or LORETA features will discriminate between normal and clinical individuals. The LOGIT of the response is the natural logarithm of the odds of success, which is defined as the ratio between the probability of success and the probability of failure. For a binomial response there is no linear model available, however modeling the LOGIT of the response yields a linear model with intercept and slopes estimations. This makes the interpretation of the model straightforward. Once the logistic regression curve has been established on large samples, the probability for a new individual to belong to the clinical group can be assessed with a point estimate (from 0 to 1.0) and a confidence interval.

Results

An example of Logistic Regression Discriminant Functions for the QEEG case is given. In the case of LORETA the methodology is identical. The discriminant function aims to assess the probability that a new individual belongs to the ADHD group (probability of success) as opposed to the Normal group (1-probability of success). Data is simulated for 100 "normal" subjects and 100 "ADHD" subjects. For QEEG the best regression model includes the theta/beta power ratio at CZ (i.e., this predictor alone yields a well-fitting logistic regression model for which the slope is significantly greater than zero). For new individuals simulated data the theta/beta ratio at Cz is considered. A direct estimation (with confidence interval) of the individual's probability to be ADHD can now be computed.

Conclusion

Logistic regression is a powerful tool for performing discriminant analysis. Since it does not require data normality, it is particularly suit-

able for QEEG and LORETA data. Several considerations are in order while applying logistic regression to QEEG and LORETA data. The major problem to overcome is the selection of the best set of predictors. In both QEEG and LORETA experiments the number of measurements largely exceeds the number of subjects. For instance, there are hundreds of coherence pairs in QEEG and thousands of voxels in LORETA. Furthermore, measurements are strongly correlated. In building a discriminant function on these data, the task is to select the most parsimonious model with sufficient discriminant power. In the case of LORETA data, spatial smoothing is required as well.

A Pre-Post Analysis of a Successfully Treated Case of Tourette's Syndrome

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Introduction

This is a single case study, which compares the pre- and post-treatment data obtained from an eight-year-old boy successfully treated for Tourette's syndrome with NeuroBioFeedback (NB). Independent pre-treatment diagnostic evaluations conducted by specialists at a major medical school teaching hospital indicated that the patient exhibited numerous simple and complex tics, uncontrolled bouts of rage and aggressive behavior, and a sequel of behavioral problems at home and at school. Multiple comorbid conditions were also noted which included ADD/HD and obsessive-compulsive behaviors. Symptomatic behavior was initially reported at age five and steadily increased in severity and complexity over time. Numerous pharmacological treatments failed to improve his condition.

Methods

Prior to treatment a comprehensive assessment was undertaken which included the following: (a) the administration of psychological, neuropsychological, and psycho-educational measures, (b) behavioral analyses were obtained form multiple observers across different contexts, and (c) a comprehensive QEEG evaluation was undertaken. A compa-

rable assessment was repeated approximately six months after the termination of treatment. After the initial assessment, thirty-five NB sessions were provided over a 15-week period. The development of treatment protocols was guided by the QEEG findings for both eyes open and eyes closed conditions. The majority of the protocols involved training SMR on the midline and in the right temporal area.

Results

After 35 ninety-minute NB sessions, administered over a 15-week period, all Tourette like symptoms were eliminated. Reports from parents and teachers indicated that the boy's behavior patterns and his conduct, both at home and school, were now well within normal limits for his age. The analysis of the psychometric data indicated significant positive changes in cognitive, affective and behavioral indices. Multiple analyses of the pre-post QEEG data indicated substantial normalization of EEG indices across many sites. In order to quantify the specific EEG parameters that changed over the course of treatment, statistical comparisons were made between the pre-post QEEG data obtained from a normative database and low-resolution electromagnetic tomography (LORETA).

Discussion

The present study provides a comprehensive and multi-perspective view of both the EEG and behavioral correlates of Tourette's syndrome and how they were altered as a result of the NB training. More specifically, the comparative analysis of the QEEG data acquired from both scalp and deep structure recordings provides an invaluable opportunity to view the pattern of neuroelectric potentials associated with Tourette's disorder as they were modified in a single subject functioning as his own control.

Comparison of Videogame & Standard EEG Biofeedback with ADHD Children: Results of the First Concept Study

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(1) EEG Biofeedback Services, Riverside Health System, Newport News, Virginia, (2) Mindspire, LLC, Chapel Hill, North Carolina, (3) NASA Langley Research Center, Hampton, Virginia (4) Eastern Virginia Medical School, Norfolk, Virginia

Introduction

This project was a randomized and controlled technology concept study, funded by NASA's Langley Research Center. The study assessed whether a new videogame biofeedback technology developed at NASA Langley Research Center was as effective as traditional neurofeedback in treating attention deficit/hyperactivity disorder (ADHD), and whether there were significant differences in its appeal as a clinical method compared to standard neurofeedback treatment.

Methods

Twenty-two children with ADHD of the hyperactive-impulsive subtype (DSM-IV criteria plus physician diagnosis) participated. The age range was 9 to 13 years and there were three girls and 19 boys. All the children were on short-acting medications for ADHD. The children had to be of at least normal intelligence, and have no history of affective problems or learning disabilities.

The children were randomized into treatment groups: videogame (n = 11) vs. standard neurofeedback (n = 11). Children in both groups completed 40 individual treatment sessions, usually seen once or twice a week. The children came for one test session before and after treatment, where they completed quantitative electroencephalogram (QEEG), Test of Variable Attention (TOVA) and neuropsychological tests. Behavioral Assessment System for Children (BASC) monitor data was collected pre- and post-treatment and every ten sessions. Children in both groups were trained with a single active Cz electrode, with reference electrode and ground attached to the earlobes.

The videogame group equipment consisted of J&J I-330 EEG hardware, a NASA-built modulation unit and a modified game controller used with a standard Sony Playstation console. Training displays were EEG-influenced off-the-shelf Sony Playstation games. The standard group equipment consisted of Thought Technology ProComp+ hardware and Multitrace Software. Displays were bar graphs and simple figures representing changes in SMR, beta and theta bands.

Results

BASC Monitor and TOVA scores indicated similar significant improvements in both groups. No significant difference in treatment change was seen in between-group comparisons. Parents' subjective

appraisal of treatment effect on ADHD was more positive for the videogame group. The videogame treatment was rated significantly more enjoyable by both parents and children. Trends on pre-post QEEG change maps indicated that the videogame training might have advantages in creating more quantitative EEG effect in the therapeutic direction.

Discussion

We conclude that the videogame biofeedback technology, as implemented in the NASA prototype tested, produced equivalent results to standard neurofeedback in effects on ADHD symptoms. Both the videogame and standard neurofeedback improved the functioning of children with ADHD substantially above the benefits of medication. The videogame technology provided advantages over standard neurofeedback treatment in terms of enjoyability for the children and positive parent perception, and possibly has stronger quantitative post-treatment effects on the EEG.

QEEG-Based versus Research-Based EEG Biofeedback Treatment with Chemically Dependent Outpatients: Preliminary Results

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Introduction

In the EEG biofeedback treatment of chemical dependency most studies have focused on alpha/theta training with some variations. One of these variations is the addition of beta/SMR training to generate physiological stability before proceeding with alpha/theta training, also known as the Scott-Peniston protocol. No studies to date have used quantitative EEG (QEEG) to guide EEG biofeedback treatment decisions. The present study examines the difference between QEEG-based treatment, research-based (Scott-Peniston) treatment, and wait-list control for chemically dependent outpatients. This presentation will focus on preliminary results in personality change and abstinence rates.

Methods

Participants were recruited from an outpatient substance abuse program and were required to remain in the outpatient program during EEG biofeedback treatment. The study consisted of four phases: (1) pre-treatment assessment, (2) EEG biofeedback sessions, (3) post-treatment assessment, and (4) follow-up sobriety measures. The pre- and post-treatment assessments were performed blind to group membership. The assessments included a structured clinical interview, IQ, academic achievement, personality, AD/HD rating scales, continuous performance test, and a QEEG.

After the intake procedure was performed, each participant was randomly assigned to one of three groups: (1) QEEG-based EEG biofeedback, (2) Scott-Peniston-based EEG biofeedback, or (3) wait-list control. In the QEEG-based group, QEEG's were analyzed using the NX-Link Neurometric database, and participants received 40 sessions of EEG biofeedback based on these results. In the Scott-Peniston-based group treatment protocols were based on a symptom checklist for the initial 10 to 15 Beta/SMR sessions, followed by the participants receiving 30 Alpha/Theta sessions. Sessions included 30 minutes of EEG biofeedback. Both types of EEG biofeedback occurred four times per week compared to 10 sessions per week in the original Scott-Peniston research. A script based on Peniston's protocol was read at the beginning of each session for both treatment groups. Talk therapy was not included as part of treatment. The wait-list control group returned after three months, completed post-assessments, was offered treatment, and randomly placed in one of the two treatment groups if desired.

Post-treatment measures included personality measures, AD/HD rating scales, continuous performance test, and QEEG. Follow-up information will include sobriety at one-month, six-months, and one-year post-treatment. At the one-year follow-up participants will be retested using the pre-treatment assessment battery.

Results

To date, seven participants have completed in each group. Both EEG biofeedback treatment groups showed improvements in personality change and maintenance of abstinence. The wait-list control group showed minimal improvements on outcome measures. Data from the Personality Assessment Inventory (PAI) were submitted to nonpara-

metric Wilcoxon matched pairs tests. Of the eleven PAI clinical scales, the QEEG group showed six significant pre-post differences, the alpha/theta group showed four differences, and the control group showed two. Of the five PAI treatment scales, the QEEG group showed three significant pre-post differences, the alpha/theta group showed two significant differences, and the control group showed no differences. All of the treatment participants have remained abstinent up to six months following treatment termination, compared to 71% of control group participants remaining abstinent.

Discussion

Although this study will be in progress until 30 participants complete each condition, the preliminary results are promising. Historically, alpha/theta training has been the accepted approach in treating chemical dependency. This study suggests QEEG-based training is a viable alternative, demonstrating similar outcomes for personality change and abstinence rates. Future directions include determination of those likely to benefit from one of the particular treatments or a combination of the two and analysis of long-term abstinence rates.

QEEG Explorations of Childhood Expressive Dysprosody

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Introduction

This case study presents a nine-year-old boy who was referred for neuropsychological assessment in order to rule out Asperger's or Nonverbal Learning Disability syndromes. While the latter diagnoses were not supported by the data, the results confirmed expressive dysprosody, alexithymia-like symptoms, and problems in verbal abstraction. The latter occurred within the context of rather well developed visual spatial, executive function and nonverbal reasoning skills.

Method

A QEEG was undertaken in order to facilitate differential diagnosis. In addition to baseline eyes-open and eyes-closed conditions, this youngster was subjected to four challenge conditions: videotape tests of nonverbal communication (i.e., the Child and Adolescent Social Perception Test), the Counting and Emotional Counting Stroop tests (used in recent fMRI studies of the anterior cingulategyrus), and a finger localization measure of inter-hemispheric transfer.

QEEGs were recorded using Lexicor NeuroSearch-24 and V151 software with an appropriate size electrocap. EEG activity was sampled from 19 scalp electrode sites in the standard International 10-20 montage with reference to ear lobes and ground just forward of site FZ. Sampling rate was 128 Hz with 32K gain.

Results

Data analysis was completed using NeuroRep Version 4.0 software (Hudspeth, 1999), which incorporates the Adult QEEG Reference Database (Hudspeth, 1999) and the Thatcher Lifespan EEG Reference Database (Thatcher, 1987). EEG waveforms were inspected offline and artifacts eliminated.

Measures of coherence, phase, and amplitude asymmetry were computed in four frequency bands among all combinations of left and right intrahemispheric sites and between homologous interhemispheric sites. Relative power for each of the frequency bands was calculated. Each of the conditions was also analyzed using LORETA.

Discussion

QEEG results are presented and discussed within the context of the neuropsychological and behavioral questionnaire results. A course of neurofeedback treatment is also discussed.

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Learned EEG Self-Regulation, Attentional Performance and Electrocortical Potentials in Healthy Subjects.

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Introduction

Learned self-regulation of electrocortical activity, such as the enhancement/suppression of frequency components of the electroencephalograph (EEG), have resulted in long term changes in cognitive and behavioral measures in clinical populations, specifically in application to epilepsy, as well as attention deficit disorder (ADD) and attention deficit hyperactivity disorder (ADHD). Effects of conditioned control over brain potentials on cognitive processing have also been reported in normal subjects, but possible benefits of "Neurofeedback training" for attentional capacities in healthy subjects have yet to be established.

A factor that has obscured the assessment of the relative efficacy of different training protocols (i.e., varying frequency bands at different scalp loci) aimed at enhancing attention is a lack of reliable prediction of successful outcomes based on relative success at learned EEG self-regulation. This study was designed to investigate the effects of two clinically applied protocols to healthy volunteers performing a sustained attention go/no-go task, and to determine whether changes in performance could be predicted from EEG responses during the training process.

A further goal was to explore possible neurophysiological mediators of attentional improvement. Reports of improved performance on go/no-go continuous performance tasks in the clinical neurofeedback literature have essentially documented an apparent effect of EEG self-regulation training on the purely behavioral measure of overall efficacy of stimulus detection, evaluation, and subsequent selection of the appropriate response. However, the neurophysiological processes and chronometry underlying this type of processing sequence have been extensively researched in other contexts by analysis of event-related brain potentials (ERPs). Of particular interest with respect to the demand characteristics of go/no-go attention tasks, as well as the distinction between automatic versus controlled stages of cognitive processing, are the Mismatch Negativity (MMN) and P300 (P3b) ERP components, which are elicited in classical oddball paradigms. MMN indexes an automatic pre-attentional process of generic stimulus change detection, while the

P3b is associated with completion of later, conscious processing of task-relevant target stimuli.

Methods

Twenty-two healthy volunteers were trained to enhance EEG activity in the 12-15 Hz band (Sensorimotor Rhythm, SMR) as well as the 15-18 Hz band (Beta1), while concurrently suppressing Theta (4-8 Hz) and higher Beta (22-30 Hz) activity over Rolandic cortex for 10 sessions of fifteen minutes. Prior and subsequent to the training process, subjects were assessed on the Test of Variables of Attention (TOVA), and EEG measures (28 electrode array) were taken during a standard auditory oddball task that included both active and passive attention conditions. Inter-test intervals were approximately eight weeks and 12 weeks for the TOVA and ERP assessments, respectively.

Results

First, the training was found to result in a significant reduction of commission errors on the go/no-go task. A regression model based on within-session learning indices of the EEG Biofeedback protocols could successfully predict performance enhancement. While learning on SMR and Beta1 protocols inter-correlated positively, the degree to which subjects learned to enhance SMR correlated positively with commission error reduction, while the degree of learned beta1 enhancement correlated negatively with reduction in commission errors, when controlling for SMR learning. This finding is in accord with prior research characterizing SMR conditioning as leading to decreased motor impulsiveness, and further supplies evidence for beta1 training not being advisable in the treatment of hyperactive conditions.

Second, it was found that in active oddball detection learned beta1 enhancement was associated with reduction in MMN and increases in P3b amplitudes, while SMR learning correlated negatively with MMN reductions. It is suggested that training of beta1 enhancement may result in an increased efficacy of top-down, expectant detection of environmental changes, while at the same time suppressing the automatic auditory mismatch response. In this context, increased P300 magnitude is interpreted as reflecting an enhanced attentional effort, facilitating the detection of an anticipated auditory percept. This efferent neural priming process overrides the indiscriminate change detector mechanism of the mismatch response in the actively attended channel only,

and hence no relationships between beta1 enhancement and mismatch suppression were found in the unattended channel. While beta1 training may facilitate attention-primed stimulus detection and in our data was also associated with faster reaction times, this response tendency seems to lead to the incurrence of impulsive errors, while the opposite may be true for SMR enhancement.

Conclusions

Our data demonstrate a successful application of attention-modulating neurofeedback protocols to healthy humans. Significant changes in both behavioral as well as neurophysiological outcome measures were found to correlate with indices of relative neurofeedback learning success, shedding light on possible mechanisms underlying training efficacy.

Differences Between Coherence and Spectral Correlation During Auditory and Visual Stimulation at Dominant Alpha Frequency

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Introduction

Although the terms "coherence" and "spectral correlation" are often used interchangeably, the former is a measure of amplitude correlation while the latter measures the consistency of phase and frequency components within a frequency band over time.

Method

To examine the similarities and differences between these two measures under controlled conditions, 30 college students received five-minute auditory, visual and combined audiovisual stimulation at the dominant alpha rhythm (DA) while a 19-channel 10-20 standard EEG was recorded. The three stimulation conditions were presented in counterbalanced order, after a five-minute eyes-closed baseline from which the DA at O1 was determined. A four-minute post-stimulation eyes-closed baseline was recorded after each stimulation condition.

Results

Coherence and spectral correlation (SC) differences from the initial baseline were evaluated among all locations at 0.75-2, 2-4, 4-8,8-12, 12-21, 21-31 Hz, and at each participant's DA, and tested for significance with Wilcoxon's sign rank test. Very few (consistent with type I error) significant effects were observed during auditory stimulation or during the post-stimulation baselines. During the visual and combined conditions, widespread, significant amplitude increases were observed in the DA, 8-12, 12-21 and 21-31 Hz bands. These conditions also increased coherence and SC frontally, interhemispherically, and in the long-range longitudinal projections in the DA and 8-12 Hz bands. Both coherence and SC increased interhemispheric coherences in the 12-21 Hz band. However, the following decreases in coherence were observed which were either not observed in SC, or observed at negligible or near-negligible levels: (a) 0.75-2 Hz, widespread (visual and combined); (b) 2-4 Hz, widespread (combined); and (c) DA and 8-12 Hz, among occipital and parietal short-range longitudinal projections (visual and combined). Coherence also showed a much broader pattern of frontal and longitudinal increases at 12-21 Hz, while SC was more broadly and diffusely increased in the DA band.

Conclusions

This study suggests limits to the validity of comparisons, which are frequently made between these two analytical measures. However, direct statistical tests between the two measures will be presented which are not included in this abstract.

Theta/Alpha Training in Application to Enhancement of Musical Performance

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Introduction

Neurofeedback aimed at facilitating a quasi-hypnogogic state of deep relaxation has been found to be an efficacious complimentary

treatment for substance abuse and post-traumatic stress disorders. This has involved rewarding an increase of theta (4-8 Hz) over alpha (8-12 Hz) activity during wakeful eyes-closed conditions. The present study integrated theta/alpha training with attention-related neurofeedback protocols and other techniques aimed at enhancing musical performance skills in conservatoire students.

Methods

One group of participants (n = 9) took part in neurofeedback training (regimes of beta1, SMR and alpha/theta protocols), while another was additionally engaged in a regime of physical exercise and a sports psychology mental skills program (n = 12), and a further group served as control group (n = 14). All students were required to perform two pieces of music of their own choice of approximately 15 minutes duration both before and after the training process. Performances were videotaped and subsequently assessed on a range of criteria by two musicians of international renown external to the conservatoire, and blind to group membership and order of performances.

Results

Students receiving only neurofeedback were judged to have improved on evaluation criteria of Overall Quality, Rhythmic Accuracy, Emotional Commitment and Conviction, and Deportment with Instrument on Stage at levels approaching statistical significance, while no trend towards improvement was detected in the other groups. More importantly, change scores in musical performance correlated significantly with indices of successful theta/alpha feedback learning but were not related to SMR or beta1 learning. In the students who had taken part in the neurofeedback training, levels of progressive linear theta/alpha ratio regression across sessions significantly predicted improvements on eleven out of thirteen musical assessment criteria ($p = .003$ to $p = .037$). This could not be attributed to reduction in pre-performance state anxiety levels.

Conclusions

Our results suggest that repeated facilitation of a deeply relaxed meditative/hypnagogic state through alpha/theta training may significantly benefit artistic expression including live musical performance. While

this exciting finding awaits replication, it points to the potential for a scope of application of the alpha/theta protocol beyond the clinical realm.

Major Depressive Disorder: QEEG Based Subtypes and Treatment Implications

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Introduction

Approximately 80 children, adolescents and adults who were sequential intakes to the ADD Clinic and met DSM IV criteria for Major Depressive Disorder were administered QEEGs. Upon analysis, 10 subtypes of power and coherence distribution emerged.

Methods

QEEG analysis was performed utilizing the NxLink NYU Normative Data Base (John, 1977), the Thatcher Lifespan EEG Reference Data Base (Thatcher, 1987), the Neurorep QEEG Analysis and Report System (Hudspeth, 1997), and the LORETA EEG Workstation (2001, Novatech EEG, 1994; Pascual-Marqui, Michel, Lehmann, Key Institute for Brain-Mind Research). A cut off of one standard deviation was utilized to determine deviation. A majority of the sample had comorbidities of ADHD and other disorders.

Results

The 10 subtypes at times occurred alone but most commonly two or more subtypes were present simultaneously.

1. Central Alpha
2. Left Frontal Alpha
3. Alpha Left > Right asymmetry
4. Central Theta
5. Left Frontal Theta
6. Theta Left > Right asymmetry
7. Midline Abnormalities overlying the cingulate

8. Lack of Left Frontal activity
9. Beta Right > Left asymmetry
10. Frontal Theta and/or Alpha Hypercoherence

Most have two or more subtypes present. Treatment has proven highly successful when based on individual subtype combinations. Treatment has required complex carefully prioritized interventions.

Conclusions

There are a wide variety of possible EEG patterns that are correlated with Major Depressive Disorder. These findings will help in the recognition of the possible presence of Depression and in greater specificity of treatment interventions. It is likely that these subtypes correlate with medication response. It is our experience that the Alpha subtypes are far more likely to respond to SSRI's than non-Alpha subtypes.

The QEEG: Everything You Need to Know Is in the Waveforms

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It would seem that we have come to expect that quantitative analyses of electroencephalogram signals (QEEG) can resolve most of our questions about brain state and, thereby, lead us directly to satisfactory neurofeedback (NF) treatment protocols. Accordingly, we can then assert the circular validity that "we only treat deviations in QEEG results (i.e., the maps)."

The validity of this assertion depends on several factors: (a) a sufficiently large number of analytic methods that can describe the relevant features in brainwave data, (b) clear evidence that numerical features relate to a common set of brain states described by signal amplitude (magnitude or power) waveform similarities (correlations, coherence, phase and perhaps co-modulation), and (c) the ability to create wide/narrow band results for each numerical index.

Visual inspection of EEG waveforms, and their sequential differences (re-montaged), provides evidence for magnitude and waveform disturbances we associate with neuropathology. Unfortunately, standard amplitude, power, asymmetry, correlation, coherence and phase

measurements do not often converge onto the same foci to identify pathological conditions. This presentation shows how neuroelectric images (NEIs) and single-band weighted average (SBWA) topographies serve to integrate waveform and amplitude measurements in a variety of pathologies.

Relationship Between Epilepsy, ADD/ADHD, LD and Retardation

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Introduction

This paper will review the EEG findings and the relationship of epilepsy in ADHD. For a complete dicussion see Hughs (1994).

Method

A review of the world literature on this topic was done.

Discussion

The relatively high incidence of EEG discharges in ADHD underscores the relationship with epilepsy, especially in Benign Epilepsy of Childhood, often with ADHD. The phenomenon of Transient Cognitive Impairment is also an example of this relationship.

Conclusion

The condition of epilepsy and the presence of EEG discharges are important conditions in ADHD.

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Efficacy of Neurofeedback for Autistic Spectrum Disorders

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Introduction

The purpose of this study was to characterize, quantify and document the efficacy of neurofeedback for individuals in the Autism spectrum.

Method

Neurofeedback, a process of neuro-regulation based on operant conditioning of EEG spectral features, has been proven to assist many with behaviors similar to those seen in the autistic spectrum. This methodology has been used successfully with those exhibiting ADHD behaviors, anxiety, sleep disorders, and addiction. Preliminary work with individuals in the autistic spectrum has shown promise. The neurofeedback protocol of augmenting specific frequencies in the 4-20 Hz region, while inhibiting excess amplitude in the lower and higher-frequency regions, challenges the brain toward more optimal functioning in terms of both physiological arousal generally, and emotional regulation specifically.

The study involved a comparison of 12 individuals trained with neurofeedback with 12 individuals who did not receive training, but continued other ongoing therapies.

Results

One hundred percent of those trained reduced their levels of autistic symptoms within months, as assessed using the ATEC (Rimland & Edelson, 1999). The average reduction in symptoms severity was 26 percent compared with a control group average of three percent. There were significant improvements on average in the areas of speech (30%), socialization (33%), health (26%) and cognitive awareness (16%). Parents also noted improvements in sleep, anxiety, tantrums, and schoolwork.

Discussion

Before and after videos were used to corroborate data. When compared with other treatment modalities using Rimland's Treatment Effectiveness Survey (Rimland & Edelson, 2001), neurofeedback is rated on a par with occupational therapy, and is surpassed to date only by behavior modification and speech therapies, even in this early-stage comparison.

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Technology Overview: Bispectral Analysis

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Introduction

Most evaluation of the EEG signal utilizes spectral analysis, which yields information about the amplitude of the EEG for each frequency band. Coherence estimates often are also generated representing the relationships among different channels for each frequency band. Bispectral analysis is an extension of commonly used frequency analysis techniques.

Methods

Bispectral analysis is an advanced signal processing technique, which is sensitive to non-linear aspects of brain function. The bispectrum quantifies the degree of phase coupling between every possible frequency pair combination.

Discussion

Bispectral analysis results in a more comprehensive description of the EEG signal and is thus able to detect more subtle changes than routine spectral analysis. Measures derived from bispectral analysis are now used to monitor the level of consciousness.

Conclusion

Measures based on the bispectrum are now used to assess altered cerebral function such as administration of anesthetics and neuroactive drugs, ischemia, and hypothermia. Potential new applications for this technology will be discussed.

Use of QEEG in Predicting Response to Medication

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Introduction

This presentation is a review of work using QEEG features to predict medication response in individuals with neurobehavioral disorders.

Methods

The studies to be reviewed use quantitative analysis of the electroencephalogram prior to administration of medications and in some cases following administration. Clinical outcome usually is assessed in relation to baseline QEEG and type of agent, or agents, administered.

Discussion

Suffin and Emory (1995) published an important study showing that specific EEG features could be identified in patients with either affective or attentional disorders, and that the presence of certain features are predictive of responsivity to specific medications. Chabot, Merkin, Wood, Davenport and Serfontein (1996) and Cook and Leuchter (2001) have published related work.

Conclusion

Studies using QEEG to predict medication responsivity in patients with neurobehavioral disorders will be reviewed and new work on these topics will be discussed.

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Rethinking Standard Bands

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Introduction

A frequency band is a compromise between ease of communication and the limits of one's analytical techniques. An argument is made for customizing EEG frequency bands to address unique characteristics of each person's cerebral organization. Individual alpha frequency (IAF), one approach to accommodating individual differences in quantitative analysis (Klimesch, Schimke, & Pfurtscheller, 1993; Doppelmayr, Klimesch, Pachinger, & Ripper, 1998), was evaluated.

Method

Peak dominant frequency for 124 adults at five posterior sites during eyes closed and eyes open rest were calculated using a standard 8-12 Hz band or the IAF technique. IAF demonstrated slightly greater attenuation to eyes open than the standard band.

Discussion

Band customization proved superior for the eyes open suppression comparison, in spite of the crudity of its calculation in this instance. Other band customization techniques are proposed. Individual differences may be the product of genetic and maturational variability or they may be indicative of cerebral pathology. Abnormal sleep spindle rhythms were identified in two autistic children. Slow spindle frequency may signify cerebral disorganization well before any behavioral symptoms emerge.

Conclusions

Frequency band customization may better optimize evaluation and training. The motor system may also play a dominant role in neuroregulation.

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Audio Visual Entrainment and Neurofeedback

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Introduction

Audio-Visual Entrainment (AVE) is often used in conjunction with neurofeedback as a priming stimulus. Recent research supports the hypothesis that AVE entrains endogenous EEG rhythms. One of the questions still remaining is whether AVE, neurofeedback training alone, or a combination of both AVE and neurofeedback is most effective to entrain EEG rhythms. This study looked at this issue. A clearer understanding of this issue would allow clinicians to choose the most effective modality to enhance neurofeedback training and thus, possibly, expedite the training.

Methods

Neurofeedback was provided using the ProComp by Thought Technology and the visual entrainment was provided using the DAVID Paradise XL by Comptronics, which produces semi-sine wave stimulation. The study incorporated four groups, a control group and three experimental groups. There were 10 participants in each group. Each of the experimental groups used a different combination of neurofeedback and visual entrainment for five separate sessions with three training trials during each session. The training spanned a three-week period. The control group (group one) had baseline frequencies recorded at the beginning of the study and again three weeks later. Each training session consisted of baseline recordings, both eyes open and eyes closed, three 10-minute training trials with eyes-closed recordings taken after each trial, and a post-training recording with eyes open and eyes closed–a post-training baseline.

Group two had three trials of neurofeedback without visual entrainment. Group three had neurofeedback only during trial one and three; during trial two they had neurofeedback with visual entrainment set within 1/2 Hz of their dominant alpha frequency. The dominant alpha frequency was determined during baseline and rounded to the nearest full hertz (for example, a reading of 10.83 will be rounded up to 11). The final experimental group (group four) had neurofeedback only during trial one and three; during trial two they had neurofeedback with visual entrainment set at least 1 Hz above their dominate alpha frequency.

As a measure of treatment effect, the following percentage differences between each experimental group were calculated: (a) initial baselines, (b) final training session recordings (session five), trial number three, and (c) post-training session (session five). The control group was included in the initial baseline calculation and the post-training calculation. To assess the significance of entrainment effects, a within-subject t-test was calculated between each experimental group's initial baseline and their final training session (session five) trial number three.

Results

This study supports the findings of other research (Frederick, Lubar, Rasey, Brim, & Blackburn, 1999; Pigeau & Frame, 1992; Rosenfeld, Reinhart, & Srivastava, 1997; Timmerman, Lubar, Rasey, & Frederick, 1999) showing that it is possible to change an individual's EEG using neurofeedback and/or visual entrainment. Statistical significance was found in key measures used in this study. The study also found that the type of training used is of great importance.

Group four had the lowest mean changes. This group did not reach statistical significance in any area. Their increases over initial baseline were lower than the other groups and their decreases from initial baseline were greater. This consistently held in all measures used. However, their group composition was comparable to the other groups with regards to age, gender, and baseline alpha readings. From these findings, it can be concluded that the independent variable, VE, set at least 1 Hz above the individual's dominant alpha reading, was significantly influential in these results.

Discussion

A possible reason for this finding is that when the VE setting is too far away from the individual's dominant alpha setting, it creates interference that may inhibit the production of alpha. In contrast, an individual that is being stimulated close to their dominant alpha frequency, as was the case with group three, may be facilitated in the production of alpha. Researchers Pigeau and Frame (1992) and Rosenfeld et al. (1997) came to similar conclusions.

Group three reached statistical significance, $p < .013$, when comparing the initial baseline to the fifth post-baseline and when comparing the initial baseline to the third trial of the fifth session, $p < .005$. Statistical significance was found in all three statistical tests used: the Paired Samples t Test, ANOVA, and the Tukey.

These results support the hypothesis that neurofeedback and visual entrainment changes do outlast stimulation; however, group three is the only group that reached statistical significance in the Tukey, $p < .005$. Clearly, the addition of visual entrainment to neurofeedback accelerates the training processes and allowed most individuals to increase their alpha. As shown from the performance of group four, however, it is critical that the visual entrainment is set within 1/2 Hz of an individual's dominant alpha. Without the knowledge of what an individual's dominant alpha is, it is recommended that visual entrainment not be used or used with extreme caution.

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QEEG Findings Among Chronic Pain Patients with Suspected Mild TBI

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Introduction

The use of QEEG findings in the differential diagnosis of Mild TBI has been greatly advanced by the development of the Thatcher mild TBI database (Thatcher et al., 1989). This diagnostic test can prove particu-

larly useful in a chronic pain population where mild TBI has been suspected as a correlate diagnosis. The first two authors of this paper have previously presented clinical data on over 300 patients in which thermal-sensory, neurologic, and psychometric data were used to differentiate a subpopulation of mild TBI chronic pain patients. All of these patients had not previously been diagnosed as brain injured despite displaying cognitive, sensory and personality changes. Most presented with multifocal body pain quite disproportionate to standard physical exam. Many of these patients had been previously accused of exaggerating their complaints and drug seeking. The present investigation examined QEEG and neuropsychological test results in two groups of chronic pain patients; those suspected of having mild TBI according to the criteria used above and those without.

Method

Twenty chronic pain patients, presenting with focal neurologic symptoms suggestive of possible TBI, were recruited as subjects for this investigation. Each subject completed a thorough neurologic examination, a set of four neuropsychological tests designed to screen for brain injury and a QEEG. All subjects were ranked according to a three-point severity scale based on a composite score of the neurologic findings and neuropsychological test results. The subjects were also assigned a severity index score as determined by the Thatcher mild traumatic brain injury discriminant analysis of the QEEG. A chi-square goodness of fit statistic was utilized to analyze the data.

Results

The QEEG Thatcher MTBI severity index score was found to compare quite favorably with the obtained composite deficit score arrived at by combining neurologic and neuropsychological test findings.

Discussion

Results of this investigation support the use of the Thatcher severity index score as an objective measure in the differential diagnosis of mild TBI in chronic pain patients. Although the present investigation was a pilot study, lacking adequate controls for medication use, patient history and other confounding variables, these findings should warrant fur-

ther studies to support the utility of the QEEG as part of a standard assessment battery when evaluating chronic pain patients suspected of mild TBI. This will have important consequences for the future medical treatment, financial and societal status of these patients.

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Event-Related Potentials in GO/NOGO Paradigm in ADHD Children During EEG-Based Biofeedback Training

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Introduction

Attention deficit hyperactivity disorder (ADHD) is the most common mental dysfunction affecting about five to 15 percent of all children. It is not a homogeneous disorder. A modern neurobiology oriented approach considers ADHD subtypes to be associated with the impairment of different neuronal circuits in the frontal lobe-basal ganglia-thalamic executive system (Castellanos, 1997; Kropotov, 1997).

Methods

To differentiate between impairments of different executive operations (engagement and disengagement operations, in particular) we measured late (in the range of 300 ms after stimulus) positive GO and NOGO components of event-related potentials (ERPs) associated with these operations in a continuous performance task in normal (N = 16) and ADHD (N = 84) groups.

Results

Our data show that the amplitude of GO and NOGO components correlate with both age and task performance. They are smaller in young

children in comparison to older ones, and in the ADHD group in comparison to the normal group. Twenty sessions of beta EEG training improved the quality of performance (decrease of omission and commission errors) and led to a significant increase of amplitude of GO and NOGO components.

Discussion

This study is the first to show that not only psychological indexes of behavior, but also "GO" and "NOGO" components of ERPs are "improved" after beta training, which in turn indicates that the biofeedback training changes the brain system for executive function.

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Effects of a Pulsed Electromagnetic Therapy on Migraine Headaches

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Introduction

The aim of this research was to evaluate the potential effects of a pulsed electromagnetic therapy (Enermed therapy) on migraine headache frequency.

Methods

The Enermed therapy consists of exposing migraine patients to very weak (50 to 100 milliGauss) electromagnetic fields pulsed at four frequencies between .5 and 25 Hz. The electromagnetic pulse generator is a small, portable device that is designed to be worn by the patient up to

24 hours a day. The frequencies the device is programmed to emit are patient specific. They are determined by an analysis of the patient's bioelectromagnetic field. The bioelectromagnetic field analysis (BFA) detects subtle energy fields emitted by the individual and through a fast Fourier transformation, converts these signals into a power spectrum that can be displayed on a computer screen.

Active treatment devices were programmed with four frequencies based on the BFA analysis. There were two kinds of control devices: active devices programmed to emit a single 2 Hz frequency, and inactive placebo devices. The primary dependent variable was the change in the average number of migraines suffered per month.

Results

Parametric and nonparametric statistical analyses showed that the group receiving the individually programmed devices had a significant reduction in the average number of migraines they experienced. There were no significant differences between the two control groups.

Conclusions

The positive results of this study are consistent with results reported by patients in retrospective surveys and prospective results others have obtained using much stronger electromagnetic fields. Furthermore, there are parallels between the observed biological and cellular effects of pulsed electromagnetic fields and systems involved in the etiology of migraine headaches. Although more research is needed, it appears that pulsed electromagnetic fields hold promise as a safe, non-pharmacological treatment for migraines.

Pills, Politics and Placebos Revisited

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This is a follow up to and extension of the "Pills, Politics and Placebos" paper presented last year and currently in press in the *Journal of Neurotherapy*. This examines recent modifications (strengthening) of the international medical ethics document (Declaration of Helsinki) and the position of the FDA and NIMH. The paper examines the ethical

standards and debate, the conditions in which placebo (sham) controlled studies may be carried out and when it is questionable. There are gray areas as evidenced by research in psychopharmacology based upon moral issues of harm and statistical and methodological issues of assay sensitivity between experimental and control conditions. This will serve as a helpful introduction to the panel regarding efficacy studies and methodology.

Anterior Alpha Asymmetry in Depression

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Introduction

Many studies have found that people with depression have less activity in the left frontal region than healthy normals. An EEG correlate of this relative reduced activity is left side alpha asymmetry. It is not known, however, if there are frontal alpha asymmetry variations between individuals with depression only compared to persons with anxious depression. This exploratory study compared QEEG records of frontal alpha of a group of seven depressed persons with those of a group of nine anxious depressed patients. Based on clinical observations, it was hypothesized that the depressed group would have more left side alpha asymmetry than the anxious depressed group.

Methods

Membership in the depressed group was defined as having an MMPI-2 Scale 2 Depression score ≥ 60 and a Scale 7 Psychasthenia score ≤ 60. The anxious depressed group membership consisted of individuals whose MMPI-2 Depression scores were ≥ 60 and Psychasthenia scores > 60. Asymmetry was calculated with the following equation: (F3-F4)/(F3 + F4) (magnitude, not power, voltage was used). EEG data were recorded on a Lexicor NRS-24 with a linked ear reference and remontaged to a Cz reference.

Results

Comparing the QEEG records of the two groups of individuals revealed that 85 percent of the depressed only group and 55 percent of the

anxious depressed group had left side asymmetry. The depressed only mean asymmetry = −.043; the anxious depressed mean asymmetry = −.0052. The depressed only group had significantly more left side asymmetry (p = .023). A surprising finding was that the anxious depressed group had higher alpha on both sides than did the depressed only group (p = .029). The mean frontal alpha, (F3 alpha + F4 alpha)/2, of the depressed only group was 11.8, and 18.0 for the anxious depressed group.

Conclusions

This increased alpha suggests that, relative to the depressed only group, persons who are anxious and depressed have reduced frontal activation in both hemispheres.

Correlations Between Version 2 and Version 3 of the Lifespan Database, and Comparison of the NYU and Thatcher MTBI Discriminants

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Many practitioners of EEG biofeedback use EEG normative databases to help guide protocol selection. There are several of these databases currently available. Little has been published about the concurrent validity of these databases. This presentation will compare different versions of the Life Span database with each other and with the NYU database. It will also compare the MTBI discriminant functions from the NYU and the Life Span databases.

There have been at least three versions of the Life Span Normative EEG Database. The first was sold by Lexicor as DataLex until the mid-nineties. The second was a revision of Version 1 and was sold with NeuroRep EEG report software. The third is also a revision of Version 1. Lexicor uses it in their QEEG report service. Nothing has been published comparing Revision 2 to 3. This paper will report on correlations between these two versions. As there are a large number of variables in the databases and the comparison sample is small, four composite vari-

ables will be created and correlations between these variables will be reported. These variables will be relative power, coherence, phase, and asymmetry.

There are two discriminant functions that use QEEG to differentiate between healthy normal individuals and those who have experienced a recent mild traumatic brain injury (MTBI). E. Roy John and his team at NYU developed one of these discriminants; Robert Thatcher developed the other. This study will compare the results from each of these discriminants for 10 individuals who have experienced head trauma without loss of consciousness in the last year.

Quantitative EEG Normative Databases: A Comparative Investigation

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Introduction

No clearly defined or universally accepted standards exist which practitioners and researchers can use to determine which QEEG database is suitable to their needs. Diverse computational and methodological approaches across QEEG databases have been vigorously defended by their respective proponents and commonly misunderstood by practitioners. The current paper aims to facilitate widespread discussion from which a universally agreed upon set of standards can be applied to QEEG databases.

Method

A broad set of criteria was developed from an extensive literature review and included issues of sampling, acquisition hardware and software, control of confounding variables, and additional issues associated with disclosure, accessibility, and screening of potential users. These were then applied to the Sterman-Kaiser, Thatcher, Hudspeth, and John databases; NX Link, 2001; Sterman, 1999; Sterman-Kaiser Imaging Laboratory, 2000; Thatcher, 1998.

Results

Results revealed reasonable concordance in data acquisition methods despite departures in inclusion and exclusion criteria and sample sizes. Significant differences were also apparent in the controls used for possible confounding variables and the relative importance given to these variables.

Conclusions

Research, clinical and ethical implications are discussed, and it is recommended that the QEEG scientific community establish peer reviewed procedures and processes which prevent database manufacturers from seducing peers and clinicians with technocratic information and techniques that appear to objectify QEEG evaluations.

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Neurocardiac Dynamics: The Relationship Between Heart Rhythm Coherence, Heart-Brain Synchronization and Cognitive Performance

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Introduction

Physiologists have studied the homeostatic functions of the cardiovascular afferent nerves for years. However, it is well established that

these afferent systems also have functions beyond those classified as homeostatic, and can influence emotional, cognitive, auditory and visual processing. In previous studies we have found that emotional states affect heart rate variability (HRV) patterns, and techniques that elicit positive emotional states lead to a distinct mode of physiological function known as physiological coherence. This mode is characterized by a sine wave-like pattern in the HRV waveform (heart rhythm coherence), entrainment of major bodily systems and a shift in autonomic balance towards increased parasympathetic activity.

While specific rhythmic breathing methods can induce coherence for brief periods, our research indicates that individuals can produce extended periods of physiological coherence by actively self-generating a sustained positive emotion. Using a positive emotion to drive the coherent mode allows it to emerge naturally and typically makes it easier to sustain positive emotions and physiological coherence for longer periods, even during challenging situations.

Methods

This study investigated the relationship between physiological coherence, heart-brain synchronization and cognitive performance in 30 healthy individuals. Subjects performed an auditory discrimination task (ADT) before and after practicing an emotional refocusing technique intended to instill a positive emotional state and increase physiological coherence. Heart rhythm coherence (derived from the ECG), respiration, pulse transit time and heartbeat evoked potentials were measured.

Results

It was found that EEG alpha activity is highly synchronized to the cardiac cycle and that the degree of alpha synchronization significantly increases during periods of high heart rhythm coherence. Increased heart rhythm coherence was also associated with significant improvements in cognitive performance (decreased reaction times). Additionally, there was a significant relationship between heart rhythm coherence and reaction times across all conditions.

Conclusions

This study suggests that techniques that increase heart rhythm coherence provide an efficient means to positively influence brain processes that regulate the autonomic nervous system, emotional experience and cognitive function.

Malingering Indicators on the Conners' CPT II

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Introduction

Due to legislation such as the Americans with Disability Act, college students that can document certain types of disabilities such as attention-deficit/hyperactivity disorder (AD/HD) can request accommodation from their education institutions. Such accommodations usually include increased time limits on tests and free tutoring services. These accommodations can become a tempting incentive for some students to feign or at least exaggerate symptoms of inattention. Likewise, some students will feign symptoms of AD/HD in hopes of obtaining psycho-stimulant medications that can be illegally marketed on campus. Continuous performance tests (CPTs) are usually included in most AD/HD evaluations as an objective behavioral measure of inattention symptoms. Unfortunately, there is little information in the literature or the test manuals to help a clinician identify evidence of a malingering attempt in the CPT results.

Methods

This study involved 70 college students (ages 17 to 25) that had no previous history of AD/HD symptoms. Before one administration of the Conners' CPT, each student was asked to complete the task to the best of his/her ability. Before the other administration of the Conners' CPT, the student was asked to read a brief description of AD/HD and was encouraged to alter the responses to simulate someone with the disorder. The order of these administrations was counterbalanced. After the trials, each student was asked to describe the strategy employed.

Results

Students were sorted into three groups based on test results. Four percent of the sample failed to simulate AD/HD symptoms. Forty-seven percent of the sample successfully feigned AD/HD symptoms, but were flagged by the Conners' CPT Report as having too many omissions. The remaining 49 percent of the sample successfully feigned an AD/HD profile on the Conners' CPT II without being marked as invalid. A con-

sistent pattern of extreme scores was observed in the latter two groups. The feigning strategy employed did not predict group membership.

Discussion

Almost half of the students were able to successfully feign AD/HD symptoms without triggering any warning from the Conners' CPT II report. These results emphasize the importance of closely examining cases involving extreme scores, verifying a previous history of AD/HD symptoms, and using additional objective measures less susceptible to malingering, such as a QEEG, as part of regular AD/HD evaluations.

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Neurofeedback for the Bipolar Child

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Introduction

Bipolar disorder has become much more commonplace as a diagnosis in childhood in recent years, affecting perhaps as many as 20 percent of children formally diagnosed as ADHD. The medical management of these children is problematic, tending toward polypharmacy with both anti-convulsants and anti-psychotics, and involving medications for which little research basis exists for children, particularly when used in combination. The same neurofeedback methods that have been found helpful in the management of seizures show promise as well for childhood bipolar disorder. The present work addresses this issue, and will include a review of how these children have been viewed historically, before the recent prominence of the bipolar designation. Related clinical categories include Impulse Control Disorder, Tourette's Syndrome, Temporal Lobe Epilepsy or Complex Partial Seizures, Obsessive-Compulsive Disorder, Intermittent Explosive Disorder, or simply anxiety and depression. The discussion of neurofeedback for bipolar disorder will be introduced by a review of neurofeedback approaches to these related clinical categories.

Methods

Several protocols were evaluated in a clinical setting to help with the stabilization of mood swings in bipolar disorder: (a) Conventional 15-18 Hz reinforcement and 4-7 Hz inhibition on the left hemisphere (C3-A1 or T3-A1), combined with 12-15 Hz reinforcement and 4-7 Hz inhibition on the right hemisphere (C4-A2, or T4-A2), (b) Variations on (a) involving tailoring of the reward/inhibit bands based on clinical responsiveness, and (c) the use of bipolar montage (C3-C4 or T3-T4) with the above frequency bands.

Results

It has been found that EEG neurofeedback can be helpful in stabilizing the physiology in bipolar disorder with a modest number of training sessions (one to three). Thus, suicidal episodes may be aborted, manic episodes calmed, and rage behavior reduced. Longer-term training can affect more lasting physiological stability and behavioral control, along with reduction in medication requirements. A preference is found for protocols that affect inter-hemispheric communication directly (protocol 3 above).

Conclusions

Neurofeedback can be effective in the management of pediatric bipolar disorder when used in conjunction with pharmacotherapy and psychotherapy. Neurofeedback, through its spatial and frequency selectivity, supports the case for hemisphere-specific failure modes in bipolar disorder, principally involving depression of the left hemisphere and mania of the right. Nevertheless, the most efficacious remedies are those that directly address inter-hemispheric communication.

Neurophysiology and Non-Linear Dynamics of Object Perception

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During the 1970s and 1980s evidence (mainly from micro-electrode studies) showed that the correlational brain processing necessary to

sensory perception is dependent on transforming the input into the spectral domain. The process is linear and invertible, the inverse transform composing an image. The procedure is similar to that used in tomography, image construction through PET scans and MRI.

The perception of objects demands a different procedure. Objects are invariant over images obtained under various perspectives. Experiments were performed in Russia, Sweden and Cornell University with persons outfitted in black leotards with white dots placed on their joints. When the persons became active the dots were perceived as forming groups. During the 19th century, Lie "invented" continuous mathematical groups to correctly describe the perception of objects.

Dots can be created through nystagmoid movements of the eyes. These pendular movements converge on point attractors. The process is a non-linear dynamic. Groups can be either linear or non-linear depending on the homogeneity of the group process.

Evidence for all these statements will be provided and discussion entertained.

Effects of HEG Training at Three Prefrontal Locations Upon EEG Ratios at CZ

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Introduction

Hemoencephalographic (HEG) training in the prefrontal area has been reported to improve regional cerebral blood flow both in tissue close to the optodes, and also in anatomically distant areas. Toomim (undated) trained brain-impaired subjects at Fp1, Fpz, and Fp2 for ten minutes apiece in each of ten treatment sessions, and found significant improvement in sustained attention and cognitive efficiency.

Method

The relative contribution of these prefrontal locations to generalized improvement in attention as measured by higher-frequency EEG activity at the vertex was investigated in the treatment of a 15-year-old, right-handed male with a history of moderate delay in development of speech, and continuing mild articulation problems and poor spelling.

He was treated with 20 sessions of combined HEG/EEG biofeedback. The primary emphasis was on increasing HEG, although bands of 4-8 Hz and 15-18 Hz from a referential recording at Cz were also displayed. Feedback in each session was conducted in three trials, with the HEG optodes placed at Fp1, Fpz, and Fp2 locations for ten minutes apiece. Order of placement was counter-balanced across trials. Changes in HEG levels within each trial were computed. This measure of voluntary control was plotted across sessions, as were the 4-8 Hz and 15-18 Hz ratios.

Results

At all three locations, the slope of increases in HEG within trials improved modestly across sessions. The ratio of 4-8 Hz and 15-18 Hz decreased clearly over sessions only in response to HEG training at Fpz.

Conclusion

The experimenter concluded that the mid-forehead site for HEG training was most efficacious in improving generalized attention. This finding will, of course, need to be replicated with subjects experiencing a variety of brain disorders.

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EEG Changes on TBI Patients During Cognitive Tasks After Cognitive Rehabilitation

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Introduction

While EEG biofeedback apparently constitutes a direct way of normalizing one's EEG, computerized cognitive rehabilitation achieves the same results, but in a more indirect way. The purpose of this study is

to test the relationship between cognitive rehabilitation and changes in the EEG patterns in TBI patients with attention deficits. The hypotheses tested are that in EO and EC conditions patients would portray a decrease in delta, theta, and alpha relative and absolute power and an increase in their beta power following cognitive training.

Method

Participants: Five TBI participants, out of medication and at least one year after their accident.

Psychometrics**: IVA, Digit Span, Digit Symbol, PASAT

EEG**: EO*, EC*, Recording during eight cognitive tasks on attention of Captain's Log (level beginner -1), EO*

Questionnaire**: 32 questions (scale 1-5)

Training: 24 sessions of Captain's Log (scale 1-5), (40 minutes each)

Psychometrics+: IVA, Digit Span, Digit Symbol, PASAT

EEG+: EO*, EC*, Recording during eight cognitive tasks on attention of Captain's Log (level beginner -1), EO*.

EEG+: EO*, EC*, Recording during eight cognitive tasks on attention of Captain's Log (level advanced -3), EO*.

Questionnaire+: 32 questions (scale 1-5)

EO*: eyes-open EC*: eyes-closed

**: Pre-training measures

+: Post-training measures

Results

Psychometrics showed improvement (at least one SD) in the following (in decreasing order): Sustained Attention, Alternating Attention, Selective Attention, Divided Attention and Focused Attention. Auditory working memory (PASAT), auditory short-term memory and sequential processing (Digit Span), and visual short- term memory as well as visual-motor coordination (Digit Symbol) showed the least improve-

ment. Improvement was equally divided into the visual and auditory field for all five case studies.

Using self-report subjects (Ss) scored higher by one point (indicating improvement) in Choice-Reaction Time (3 Ss), Divided Attention (3 Ss), Selective (2 Ss), Confusion (2 Ss), Simple-Reaction Time (2 Ss), Alternating Attention, Verbal Memory Impairment and Non-Verbal Memory Impairment, in Long-Term Memory, Sustained Attention and Anterograde Memory.

The most significant EEG differences seen were decreased EC theta, alpha and beta absolute and relative power after implementation of cognitive rehabilitation training. Similarities in the EEG changes after training among the three participants of similar age and left hemisphere were noted. Females shared more common EEG changes after training, mainly in EC absolute power in theta, alpha and beta and in EC relative power in alpha and posterior beta. Males showed EC absolute and relative power increase delta and theta. EC absolute power theta, alpha and beta, EC relative power, delta, alpha and posterior beta, and EO absolute power for frontal and central beta showed the most prevalent significant changes.

Conclusions

In the five TBI Ss studied psychometrics demonstrated improvement in attention (mainly in sustained, alternating and selective attention) following cognitive training, and correlate with self-reports. EEG changes accompanied these improvements. Further analysis of the EEG changes is underway. These findings need to be replicated in a larger study.

QEEG-Guided Neurofeedback in the Treatment of Epilepsy: An Up-Date for the New Millennium

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Introduction

Neurofeedback had its origins in animal studies documenting protection against drug-induced seizures following EEG operant conditioning. These were normal animals being trained to enhance a naturally occurring EEG pattern associated with a unique state of suppressed

sensorimotor excitability (the Sensorimotor Rhythm, or SMR). Findings from a series of studies in a number of laboratories confirmed that enhancement of the SMR with training was accompanied by a host of physiological changes that were consistent with an anticonvulsant effect. The extension of this work to human seizure disorders documented therapeutic effects but also disclosed a number of problems not encountered in the animal work. Advances in electronics and computer quantitative analysis have helped to address these problems, and have allowed for objective documentation of therapeutic effects.

Methods

Starting with our earliest group studies, EEG data were collected from as many cortical sites as the computer equipment of the period allowed. Patients had variable neuropathology, complex anticonvulsant drug regimens, and different personal histories. The approach applied concepts of EEG operant conditioning established in the animal work to achieve a localized EEG normalization based on the limited information available. In recent years the emergence of expanded cortical EEG monitoring capability and associated quantitative analysis has enabled the development of more comprehensive training protocols but still directed towards the concept of EEG normalization through focused operant conditioning.

Findings

When compared to non-epileptic controls, seizure disorder patients were found to be statistically deficient in the human equivalent of the sensorimotor EEG pattern. These patients also had generalized and/or focal EEG abnormalities that could not be directly addressed with the limitations of earlier technology. Nevertheless, dozens of peer-reviewed studies have confirmed seizure reductions associated with neurofeedback training attempting to apply the SMR model from animal studies. In many cases EEG normalization was also documented. More recent efforts, based in clinical rather than laboratory settings but using advanced QEEG and neurofeedback methods, have resulted in consistent seizure reductions, the ability to reduce anticonvulsant medications, and the normalization of EEG patterns as documented through objective QEEG findings.

Conclusions

Properly administered EEG feedback training is an effective alternative treatment for some types of seizure disorder. Generalized major-motor and partial-complex seizure types have responded best. Improvements are seen also in cognitive functions. Assessment with multi-channel QEEG analysis has facilitated treatment outcomes, and provided for their objective evaluation.

Combined Neurofeedback and Biofeedback for Dystonia and Parkinson's Disease: Theory and Case in Progress

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Introduction

This paper presents a theoretical framework for using a combination of neurofeedback and biofeedback with clients who have dystonia (or a combination of dystonia and Parkinson's Disease). Initial work has demonstrated promising results in terms of symptom relief and an improvement in the quality of life.

Method

A 45-year-old female patient with severe Parkinson's combined with dystonia was trained to increase SMR (13-15 Hz) and decrease high beta (23-32 Hz) activity. At the same time she was trained with biofeedback to breathe diaphragmatically at a rate of six breaths per minute (BPM) and to decrease her forehead EMG microvolt level. The breathing rate of six BPM was chosen after a stress test demonstrated that, at this rate, heart rate variability was in synchrony with her breathing. She had 35 sessions of neurofeedback combined with biofeedback.

Results

Following training, the patient was able to control the episodes of 'freezing' (when she was completely unable to move) by employing diaphragmatic breathing which she was trained to associate with SMR production, and almost immediately regains motor control. She is also

able to control dystonic movements using the same self-regulatory procedure.

Discussion

The use of neurofeedback combined with biofeedback hinges on the fact that muscle spindles, which are involved in muscle movement and tone, have double innervations, cholinergic and sympathetic. Both of these systems can be operantly conditioned with the possible effect of decreasing undesirable muscle movement and tone. Gamma efferent fibers from the ventral horn of the spinal cord to the contractile ends of the intrafusal muscle fibers receive input from supra-spinal efferents, which can arise from the red nucleus. The muscle spindle in turn sends somatic afferent fibers back to the red nucleus. This results in a feedback pathway from the muscle spindle, which influences the activity of the red nucleus in the midbrain. The red nucleus has been shown to decrease firing when the thalamus is producing the spindle rhythm that Sterman named Sensorimotor Rhythm (SMR) (Sterman, 2000). Sterman demonstrated that SMR could be trained by means of operant conditioning. Theoretically, training to increase SMR could decrease muscle tone and, perhaps, unwanted movements. Simultaneously training for calm relaxed sympathetic/parasympathetic balance in autonomic nervous system functioning might also have a direct beneficial effect on muscle tone by means of the sympathetic influence (Grassi, Filippi & Passatore, 1986) on muscle spindle activity. To attain this balance in the autonomic nervous system the client is taught diaphragmatic breathing and to increase the amplitude and quality of RSA (respiratory sinus arrhythmia, also termed heart rate variability entrainment). This training has a second possible beneficial effect. Breathing deeply and diaphragmatically at a rate of six BPM can be used by clients to cue themselves to turn on a mental state associated with an increase in SMR.

Conclusion

In this client the combination of neurofeedback and biofeedback has resulted in an improved quality of life and a reduction in medications with improved control of symptoms. Improvements became apparent after a dozen sessions. She has had a total of 35 sessions and at this juncture, eighteen months. This patient has undergone many different pharmacological treatments with no lasting improvement in her symptoms. Now, one and a half years after beginning biofeedback, her gains are be-

ing maintained. The authors emphasize that this work is reported solely to put forth a theoretical model and encourage research in this area.

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Task-Related EEG Alpha Desynchronization During a Cognitive Flexibility Task in Good versus Poor Performers

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Introduction

Alpha oscillations during cognitive performance have mostly been studied in memory and/or (basal) attention tasks. The present study investigates task-related alpha power desynchronization (TRD) in a cognitive flexibility test requiring higher executive attentional control. Alpha power responses are also studied in good versus poor performers.

Methods

Participants were 23 paid volunteers (12 males and 11 females, age 46.4 years, education 12.6 years). Since the verbal flexibility task measured executive attentional control, the EEG was recorded at AF3 (according to the expanded 10-20 system). Horizontal and vertical eye movements were measured simultaneously. In order to follow the same rationale as in ERD/ERS research, task-related power decrease/increase relative to an eyes-open resting baseline (EO) was calculated during a computerized cognitive flexibility task that required a steady-state task performance (i.e., with repetitive cognitive challenges within a time window of less than 2000 msec). Two subtests with different task

difficulty were used: a two-choice RT digit test (50 trials) and a flexibility test in which attention needed to be alternated between letters and digits (100 trials). Measures used were median RT, SD of the RT (performance variability), and the number of errors. Subjects were divided in two groups based on their normative performance for each of the three mentioned parameters. Good performers scored above average, superior or very superior. Poor performers scored below average or borderline abnormal. All groups but one were matched for age and educational level. The number of years of education was significantly higher ($p = .044$) in the stable performers (13.7 years) compared to the variable performers (10.6 years). Previous research has suggested functional differences in the lower alpha band (8-10 Hz) and upper alpha band (10-12 Hz). Therefore, alpha power changes were studied in the 8-12 Hz, 8-10 Hz and 10-12 Hz ranges. Test scores on other neuropsychological tasks (WAIS-R Digit Span: forward and backward, Symbol Digit Modalities Test, Trail Making, Five-Point Test, Wisconsin Card Sorting, and Critical Flicker Fusion Frequency), administered within the same session, were compared between good and poor performers on the Flexibility Test and with respect to their alpha EEG reactivity. Between-subject analyses were performed using Mann-Whitney tests, and for within-subject comparisons Wilcoxon matched pairs tests were used.

Results

Good performers, who made no errors (only one of them made one error) ($N = 12$) during the flexibility task, showed in the difficult task relative to EO a significant TRD in the 8-10 Hz range ($p = .034$). They also tended to produce such a TRD in the difficult task relative to the easy one ($p = .084$). In contrast, in those who made between six and eleven errors ($N = 5$) a task-related synchronization (TRS) appeared in the 10-12 Hz range relative to EO during both the easy task ($p = .043$) as well as during the flexibility task ($p = .043$). Moreover, the good performers had a greater backward digit span ($p = .051$). Critical flicker fusion frequency, measuring CNS activation, also tended to be higher in these good performers ($p = .105$). With respect to the median RT, the group of fast responders ($N = 7$) generated a TRD in the 8-10 Hz range during the difficult task relative to EO ($p = .018$). Slower performers ($N = 9$) did not show significant alpha responses during task conditions. No significant differences in the other neuropsychological test scores were found. A different 8-10 Hz reactivity between stable performers ($N = 7$) and variable performers ($N = 5$) during the difficult task relative

to the easy one (p = .007) was the result of a TRD in stable performers (p = .018). In addition, stable performers drew more unique designs in three minutes (p = .047) indicating a better design fluency that may be explained by their higher level of education. Furthermore, they also tended to perform better on the Trail Making Test-Part A (p = .068), the SDMT (p = .103), and the Critical Flicker Fusion Frequency Test (p = .092).

Conclusions

Significant task-related 8-10 Hz desynchronization was found only during the difficult flexibility test and only in good performers. In contrast, poor performers, who made at least six errors during the flexibility task, hypersynchronized in both the easy and the difficult task within the 10-12 Hz range, probably reflecting cognitive overload. Slow or variable performers generated no significant TRD. In line with previous research, the differential alpha responses considered together with their related neuropsychological test profiles, may indicate functional differences. Interpreted within the framework of attentional functioning, the 8-10 Hz band appears to be more associated with alertness and information processing speed, whereas the 10-12 Hz range seems to be more related to attentional control.

QEEG Reference Database Evaluation of Adult ADHD

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Introduction

In a recent study of adults with attention deficit hyperactivity disorder (ADHD), it was discovered that approximately 50 percent of the ADHD sample demonstrated greater impairment than their colleagues as evidenced by at least two of the three Attention Quotient scores on the Intermediate Visual and Auditory Continuous Performance Test (IVA, White, 2001). Furthermore, these same individuals with greater impairment on the IVA demonstrated significantly higher theta/low-beta power ratios at Fz as compared to their ADHD colleagues during other neuropsychological tasks. Overall, these ADHD individuals dem-

onstrated higher theta/low-beta ratios across all three tasks and concurrently demonstrated greater attentional impairment on the IVA. This finding speaks to potential diversity in the manifestation of this disorder in relatively high functioning adults and the need for the examination of possible quantitative electroencephalographic (QEEG) variations within this diagnostic category.

One method used to identify potentially pathognomic QEEG variations is the incorporation of a QEEG reference database. There are several such databases available, but to date, a comparison of databases has not been performed in the attempt to identify a specific clinical population. As such, to further evaluate the ADHD subjects described above, the current investigation will compare the results of analyses from two such databases. The databases that will be used in the present study are those associated with the NeuroRep QEEG Analysis and Report System (Hudspeth, 2000) and the SKIL Topometric Software Package (Sterman & Kaiser, 2000).

Method

Participants. The study sample consisted of 10 adults with ADHD (six males and four females), ranging in age from 21 to 47 years old. Informed consent was obtained per the University of Tennessee, Office of Compliances, Institutional Review Board guidelines. Inclusion criteria required that participant be formally registered with the Office of Disability Services at the University of Tennessee with a diagnosis of ADD or ADHD. Participants were also required to demonstrate clear characteristics of the disorder as measured by personal endorsement of at least six of nine hyperactive-impulsive items or at least six of nine inattentive symptoms as indicated from diagnostic criteria on a DSM-IV symptom checklist for ADHD.

Exclusion criteria included: (1) an obtained standard score less than 85 on the Peabody Picture Vocabulary Test, Third Edition (PPVT-III), (2) a history of neurological disorder, head injury, or substance abuse, and (3) previous diagnosis of specific learning disabilities, as assessed though the health history questionnaire and personal interview. To control for medication effects, ADHD participants being treated with stimulant medication were evaluated after a medication-free period of at least 12 hours.

Electroencephalograph (EEG) Recording. The quantitative referential EEG was recorded from 19 electrodes in an array following the International 10-20 Placement System (Jasper, 1958) with linked earlobe

references. Standardized preparation procedures involved all electrode impedances being maintained at or below 5 KOhms. The raw EEG was collected using a Lexicor NeuroSearch-24 electroencephalograph with a sampling rate of 128 samples per second.

Procedure. Participants reported to the Brain Research and Neuropsychology Laboratory in order to obtain informed consent, completion of the screening measures, and EEG recordings with all tasks completed in a single, two-hour appointment. All data collection was performed between the hours of 8 a.m. and 1 p.m. EEG recordings were made using a fitted electrode cap (Electro Cap Inc.). There were additional bipolar recordings at the outer canthus of each eye and above and below the left eye to monitor horizontal and vertical eye movements, respectively.

All participants completed five QEEG recordings during two baselines and the three different test conditions. The conditions included a three-minute eyes-closed resting baseline, three-minute eyes-open resting baseline, administration of the Paced Auditory Serial Addition Test (PASAT), administration of the Wisconsin Card Sorting Test, Computerized Version (WCST: CV3), and administration of the IVA. The order of administration remained standard for all participants.

Results

Following artifact rejection using the EEG Editor (Congedo, 2001) EEG data review and editing package, data files for the eyes-closed and eyes-open resting baselines for each participant will be submitted for analysis to both the NeuroRep QEEG Analysis and Report System (Hudspeth, 2000) and the SKIL Topometric Software package (Sterman & Kaiser, 2000). Database comparisons will be generated for each package following established guidelines. The results of the respective analyses will then be compared and contrasted including a synopsis of the unique characteristics of each package.

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