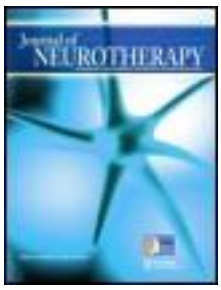

Journal of Neurotherapy: Investigations in Neuromodulation, Neurofeedback and Applied Neuroscience

Selected Abstracts of Conference Presentations at the 2008 International Society for Neurofeedback and Research (ISNR) 16th Annual Conference, San Antonio, Texas

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PROCEEDINGS OF THE 2008 ISNR CONFERENCE

Selected Abstracts of Conference Presentations at the 2008 International Society for Neurofeedback and Research (ISNR) 16th Annual Conference, San Antonio, Texas

The 16th annual conference of the International Society for Neurofeedback and Research (ISNR) was held in San Antonio, Texas, on Labor Day weekend 2008. More than 400 people attended this meeting, and Leslie Sherlin, PhD, Conference Committee Chair, was congratulated numerous times for organizing such a wide-ranging and successful venture. If you happened to miss the meeting, or missed a talk or two, what follows are presentation abstracts along with the e-mail addresses of the presenters whenever available.

David A. Kaiser, PhD
Editor

Pre- and Post-QEEG and Neuropsychological Effects of Left Frontal Magnetic Stimulation (rTMS) in Depression

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Background

rTMS treatment for depression has been under investigation in many controlled studies over the last 20 years. These studies have shown mixed results. Most studies used a single stimulation protocol to treat all patients in the same way. Furthermore, the population investigated consisted of treatment-resistant depressed patients. Little is known about interindividual differences, contraindications for treatment, and the neurobiological action of rTMS in patients. We therefore developed a personalized stimulation protocol based on the QEEG and neuropsychological data and investigated pre- and posttreatment effects on QEEG and neuropsychology.

Methods

rTMS treatment was applied in 8 participants for a maximum of 20 sessions to the Left Dorsolateral Prefrontal Cortex (Left DLPFC). Prior to treatment clients were assessed on a full QEEG and neuropsychological (IntegNeuro) evaluation. First, potential contraindications were investigated, for example, paroxysmal EEG activity and focal excessive beta spindles. Clients were stimulated over the left DLPFC with 10 Hz rTMS. Furthermore, rTMS treatment was complimented by cognitive behavior therapy.

Results

All participants showed full remission within 20 sessions and there was a 65% reduction in depressive symptomatology (BDI score) in 15 sessions. There was also a clear decrease in the Neuroticism scale of the NEO-FFI personality questionnaire. Pre- and post-QEEG, neuropsychological assessments, and ERP effects are currently under analysis and will be reported during this presentation.

Discussion

The results of this pilot study demonstrate that rTMS is an effective and safe treatment for patients with depression. Pre- and post-QEEG measurements, neuropsychological assessments, and event-related potentials will be presented during this presentation.

Optimizing Microsurgical Skills with EEG Neurofeedback

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Background

Neurofeedback has previously been found to improve cognitive performance as well as artistry by enabling individuals to self-regulate their brainwave activity. We assessed whether two distinct EEG neurofeedback protocols could enhance surgical skill, given the decisive role this skill plays in medicine.

Methods

NHS trainee ophthalmic microsurgeons ($N = 20$) were randomly assigned to either sensorimotor response (SMR) and Alpha-Theta (AT) protocols or a waitlist "no-treatment" control group ($N = 8$) subsequently randomized to the training protocols. Both groups received eight 30-min sessions of EEG training. Pre- and postassessment included a skills lab surgical procedure with objective timed measures and expert ratings from video recordings by consultant surgeons, together with state/trait anxiety self-reports.

Results

SMR training demonstrated advantages not present in the control group. There was improvement in surgical skill according to (a) the expert ratings: overall technique ($p < .038$) and suture task ($p < .018$; judges' reliability, $r = .85$); (b) task speed (total task time, $p < .021$), whereas everyday anxiety (trait) decreased by circa 10% ($p < .017$), and of importance, the decrease in anxiety and surgical task time were both associated with EEG training change.

AT training produced marginal improvement, evinced by overall performance time reduction, which was accompanied by a large standard error indicative of uncontrolled individual differences. Notwithstanding, successful within session elevation of the theta-alpha ratio correlated positively with overall technique ($r = .64$, $p = .047$).

Interpretation

SMR neurofeedback training provided significant enhancements in surgical technique while considerably reducing time on task by approximately 25%. There is also evidence that AT training marginally reduced total surgery time, despite suboptimal training efficacies. All in all the data set provides encouraging relationships validating the optimizing of performance on a complex professional skill through neurofeedback training.

EEG Phenotypes Predict Treatment Outcome to Stimulants in Children With ADHD

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This study shows that the EEG Phenotypes as described by Johnstone, Gunkelman, and Lunt are clearly identifiable

EEG patterns that can be classified with high reliability by two raters. Furthermore, it was also demonstrated that these EEG phenotypes occurred in both attention deficit hyperactivity disorder (ADHD) participants as well as healthy control participants. The Frontal Slow, the Slow Alpha Peak Frequency, and the Low Voltage EEG Phenotype seemed to discriminate ADHD participants best from the control group, however, not significantly. The frontal slow group responded to a stimulant with a clinically relevant decreased number of total errors and false negative errors on the CPT. It also became very clear that the two most prevalent EEG Phenotypes—Frontal Slow and Slowed Alpha Peak Frequency—have in previous research most likely shown up as the typically found frontal theta group, whereas these two EEG Phenotypes have very different etiologies as evidenced by the treatment response to stimulants and the autonomic interrelations.

This implicates that all future research employing EEG measures in ADHD should avoid using filtered data only, but first establish whether a frontal slow or a slowed alpha peak frequency is present. Furthermore, the severity of the phenotype divergence from normal is greater in the clinical group than in the controls. This demonstrates that not only the presence of a phenotype but also the magnitude of the deviation from normal is related to ''normalcy.'' Investigating EEG Phenotypes seem to be a promising new way to approach EEG data, explaining much of the variance in EEGs and thereby leading to more specific prospective treatment outcomes. We have chosen not to do pre–post statistics on this small group but will perform the effort when we get a larger group where the statistical power actually makes some sense.

An Evolutionary Approach to Brain Rhythms and Its Clinical Implications for Brain Modulation

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Introduction—Evolutionary Approach to Functional Anatomy

We have a brain because we need one. Evolution has created the brain that fits the environment. Looking at the evolutionary stages, a phylogenetically old automatic autonomic archencephalic reflex can be modified by an evolutionary more recent paleencephalic brain structure, dimming or increasing the response. This modulated response can, at a later stage of evolution, become integrated into a neencephalic plan and ultimately result in a controlled execution of the planned response.

Motor/autonomic responses require some cost/benefit (C/B) instructions, deciding about the allocation of responses in relation to various reinforcers. The nucleus accumbens, being a C/B instructor might instruct the ventral and dorsal striatum to form conditioned responses (both Pavlovian and operant) to the stimulus that released a burst in the VTA with resultant dopamine boost in the nucleus accumbens and prefrontal cortex.

Evolutionary Approach to Brain Functioning (Extending the Polyvagal Theory)

Steven Porges has described the polyvagal theory, based on a phylogenetic approach. Based on dopamine lateralization in controllable and uncontrollable stress and based on the lateralization studies of the autonomic system performed by Oppenheimer the polyvagal system can be heuristically extended to a five-step mechanism. At rest the myelinated vagus, controlled by the left insula is predominantly active (rest and digest). When a stimulus arrives that needs to be responded to (controllable stressor) the right insula is coactivated adding some sympathetic drive to the parasympathetic activity. When stress becomes uncontrollable the left insula shuts down vagal nerve activity and only right insular sympathetic activity prevails, and when stressors become life-threatening the activity shifts back to the left insula activating the unmyelinated vagus resulting in extreme rest (death feigning).

Evolutionary Approach to Brain Waves

Primitive species, requiring little information processing suffice with slow oscillations, whereas phylogenetically more recent species such as humans have enormous processing going on, demanding more of the fast oscillations. The frequency of paleencephalic emotional pathways in the brain might be theta band activity, whereas the phylogenetically more recent cognitive activity might be alpha based.

The frequency of the spontaneous oscillations in the EEG and the level of consciousness are correlated: the higher the frequency and the lower the amplitude of the EEG, the higher the level of consciousness. Data from multiple sensory systems suggest that gamma waves (30–80 Hz) are a prerequisite for conscious perception of a sensory stimulus. Thus sensory awareness is correlated to gamma band activity in the sensory thalamocortical system. Synchronization of separate gamma-band activities, present in different thalamocortical columns, is proposed to bind distributed neural gamma activity into one coherent sensory percept.

However, studies in the olfactory system suggest that gamma activity is nothing more than a carrier wave and that the information transmitted occurs via amplitude modulation of the gamma carrier wave. One way of retrieving the information content is to decompose the gamma band activity via independent component analysis. If the other frequency bands are also carrier waves one message can be processed simultaneously by separate circuits, for example, limbic at delta/beta and cognitive at theta/gamma.

Bringing It All Together: A Hypothetical Tinnitus Model

At rest the auditory cortex oscillates at alpha frequencies (8–12 Hz). When there is hearing loss, the deafferented cells will initially oscillate at lower frequencies (4–7 Hz) because there is less information to be processed. Because of a decrease in lateral inhibition, there will be an associated halo of gamma band activity (30–80 Hz). This is called thalamocortical dysrhythmia.

At rest the limbic system oscillates at theta frequencies (4–7 Hz). When there is a deafferentation of limbic input associated with a sensory deafferentation (via the nontopographic pathways) the deafferented limbic cells will initially oscillate at lower frequencies (1–3 Hz) because there is less information to be processed. Because of a decrease in ateral inhibition, there will be an associated halo of beta band activity (13–30 Hz). This is what is noted in distressed tinnitus patients in a right-sided ''distress network,'' consisting of the amygdala, anterior cingulate, anterior insula, and BA10 (prefrontal cortex). By analogy this could be called limbic dysrhythmia. Synchronization of the thalamocortical dysrhythmia and limbic dysrhythmia—by, for example, phase synchrony—could then result in tinnitus distress.

Predictions

Based on this evolutionary heuristic model the following suggestions/predictions can be made:

- NFB as a form of operant conditioning can be most powerfully performed using implanted electrodes in the VTA or nucleus accumbens.
- NFB might be strengthened by dopaminergic medication targeting D1 receptors.
- NFB at different targets should focus on restoring normal FFT activity of the dysfunctional circuit involved, for example, alpha for tinnitus intensity, theta for tinnitus distress.
- NFB should aim at treating spectrally filtered and subsequently ICA decomposed activity.
- NFB should consider lateralization for modulation of limbic/autonomic activity.

The SMR Story: Sleep, Motor Regulation, and Memory

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The discovery of an EEG rhythmic pattern in the sensorimotor area of cortex

in alert but motionless cats, dubbed the sensorimotor rhythm (SMR), was of particular interest because of its similarity to the unique "spindle-burst" pattern seen in the EEG of cats and humans during quiet sleep (Sterman & Wyrwicka, 1967). Both were in the 12–15 Hz frequency range over this general region and both were associated with the absence of spontaneous motor behavior. In addition, the SMR appeared when animals were trained to suppress a learned motor response. To test the possibility that the changes in motor regulation in both states were related, a study was carried out in which cats were trained to produce the SMR directly in an operant conditioning paradigm, and sleep EEG and structure were measured before and after this training (Sterman, Howe, & Macdonald, 1970). When compared to an alternate EEG training condition in a counterbalanced, crossover design, sleep spindle density was significantly increased and the duration of sleep periods prolonged only following the SMR training condition.

A follow-up study with random assignment and double-crossover design provided SMR and control EEG training conditions to human participants. Sleep studies obtained before and after these training periods revealed a significant and unique increase in sleep spindle density specifically following SMR training. Collectively, these finding suggested a functional link between the SMR and sleep-spindle EEG patterns that was subsequently investigated by others. Hauri (1981) found that SMR neurofeedback training significantly improved the sleep of so-called idiopathic insomniacs who were not suffering from stress or transient tension. More recently Verstraeten, in a blinded, randomized, placebo controlled study, found that SMR training sessions prior to sleep significantly improved sleep latency, sleep stability, and sleep efficiency in a group of healthy adults, whereas Hoedlmoser and others (in press) obtained similar results in a randomized, controlled study of SMR training and sleep but also demonstrated a significant increase in sleep SMR frequency and spindle number. Further, they found significant improvements in memory performance in SMR-trained participants after sleep. The involvement of SMR training in motor regulation and learning potentiation appears to mediate these outcomes.

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A Proposal for Combining Measures of Electric, Magnetic, and Chemical Gradients to Optimize Brain Imaging of Large-Scale Activity

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The common factor that underlies several techniques for brain imaging is the electric current by which dendrites express the magnitudes of their responses to synaptic inputs, sum them, and transmit their sum to the trigger zones of axons for transmission without attenuation locally and to the far reaches of the central nervous system. The high current densities in parallel dendritic shafts support magnetic field gradients of sufficient intensity to be detectable several centimeters from the scalp in the MEG. The broad distributions of the loop currents outside the dendrites manifest electric field gradients observed in potential differences in the scalp EEG. The prodigious demands for the energy that is required to drive the dendritic currents are met by metabolic and hemodynamic responses (inclusively "chemical gradients") that are observed with PET, BOLD, fMRI, and related techniques.

For all three of these state variables the relationships between the intensities of neural electric current density and the electric, magnetic, and chemical gradients are complex and far from proportionate. The observable state variables are complementary because the information they convey comes from differing sources, so that efforts to cross-validate localization of neural activity relating to specified cognitive behaviors have been disappointing. A more appropriate use for the three methods in combination is proposed through the noninvasive study of large-scale, high-resolution spatial patterns of neural oscillatory activity in the beta and gamma ranges. This approach would use multivariate statistics to classify and evaluate nonlocal macroscopic brain activity patterns that simultaneously occupy both gyri and sulci in the cerebral hemispheres. To the extent that various sensors obtain samples over comparable time segments, this approach may support cross-validation of the techniques and provide for better modeling of the multifactorial nonlinear relations between each observable state variable and the underlying neural activity.

Whole-Brain Functional Training Using Multivariate Proportional Z Scores

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This talk will describe a new method and present clinical results with a new method of training EEG connectivity and differential brain activation. This approach uses a novel multivariate approach to using normative EEG statistics. The method is based on the creation of new feedback variables, which are derived from live Z scores, in combination with other training criteria. This method goes beyond conventional single-component training and employs multiple brain metrics including absolute and relative power, power ratios, coherence, phase, and asymmetry. Values may be used individually or in various combinations. In its fullest expression, the method creates a simple training variable that reflects a comprehensive set of brain states and trains the brain to seek them. This results in whole-brain training while avoiding some important limitations of single-component training. QEEG studies of pre- and post-assessments clearly show that this method is capable of resolving multiple EEG abnormalities and that the system successfully targets relevant abnormalities, without the need to design specific protocols.

Systems Theory of Neural Synergy: Neuroanatomical Underpinnings of Effective Intervention Using Neurofeedback Plus Biofeedback

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Introduction

Clinical experience indicates that, for the most part, clients present with problems in five key areas. These are (a) attention deficit hyperactivity disorder (ADHD) symptoms of inattention and impulsivity; (b) anxiety, depression, and affect modulation; (c) empathy, affect interpretation, and expression and maintaining social interactions; (d) executive function difficulties including learning and memory; and (e) movement problems, including tics. A comprehensive understanding of the interplay of central nervous system (CNS) components that underlie these difficulties requires that the practitioner perceive the human nervous system as a dynamic network of interconnecting elements that is constantly working to maintain homeostasis and equilibrium. Input to any element within the nervous system will produce change in the other elements of the system. These elements are synergistic; they work together producing correlated action where the product is always greater than the simple sum of the parts primarily involved. This is the basis of our work with hundreds of clients and we have recently developed the Systems Theory of Neural Synergy (STNS) to explain why it works to combine neurofeedback, biofeedback (polyvagal theory), cognitive strategies (CS), and at times music therapy. Each approach feeds back to and through

the CNS and supports and facilitates the feedback through other modalities. The participants will be introduced to how lack of normal functioning in cortical, diencephalic, corpus striatum, midbrain, and brain stem regions can correspond to the clients' symptoms.

Method

Clinical assessment including 19 channel quantitative electroencephalography plus low-resolution electromagnetic tomography, indicates areas of dysfunction that correspond to a client's symptoms. As an example, in autistic spectrum disorders including Asperger's, these include (a) prefrontal cortex, (b) hippocampal gyrus, (c) amygdala with its connections to the orbital and medial frontal areas of the brain, (d) fusiform gyrus, (e) superior temporal gyrus containing the auditory cortex, (f) anterior insula and the anterior cingulate (both part of the limbic system, or emotional brain), and (g) frontal and parietal-temporal mirror neuron areas (on the right side underlie sensory and motor aprosodia). Stephen Porges's polyvagal theory demonstrates how many of the symptoms observed in ASDs also have brain stem components that can be constructively influenced by creating a "safe" environment with biofeedback and sound feedback. For the majority of clients, recovery from stress is an additional difficulty and this can be demonstrated using a psychophysiological stress assessment. Intervention encompasses appropriate feedback to normalize the EEG and increase heart rate variability while relaxing muscles and increasing skin temperature, and coupling these feedback approaches with appropriate cognitive strategies for the particular client. Operant and classical conditioning come into play.

Results

The authors have presented and/or published on the successful outcomes of this approach for more than 150 clients with ADHD and another group with ASDs (145 with Asperger's and 9 autistic). They have also published on methodology and successful outcome with anxiety/depression and stress and on movement disorder. The measurement of clinical success will be shown with data from case series.

Conclusions

The STNS helps the practitioner to understand the CNS as a gestalt. This leads to a foundation that supports the combined use of NFB, BFB, and cognitive strategies to ameliorate the presenting problems of clients.

LORETA Neurofeedback in the Cognitive Division of the Anterior Cingulate Gyrus in Monozygotic Twins Concordant for Attention Deficit/Hyperactivity Disorder

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Introduction

This study examines the effects of LORETA Neurofeedback (LNFB) in the cognitive division of the anterior cingulate gyrus in monozygotic twins concordant for Attention Deficit/Hyperactivity Disorder (ADHD).

Methods

Two 24-year-old men concordant for ADHD (predominantly inattentive type) since childhood underwent LNFB sessions: Twin 1 (T1) completed 30 sessions; Twin 2 (T2) completed 15 sessions. Each session consisted of pre- and post-3-min eyes-closed and eyes-opened baselines and four 5-min training rounds conducted three times per week. We trained the individuals to increase 14–18 Hz activity on the AC. Learning was assessed by electrophysiological measures.

Results

Frequency analysis indicates significant learning occurred in the AC over sessions for T1 and in regions shown to share functional connectivity with the AC. Although

T2 completed less sessions moderately significant learning is shown. Frequency specific learning curves are shown in theta, alpha 2, and beta frequencies, with significant decrease in delta in frontal regions.

Discussion

Further region of interest analysis suggests the trained frequency influences regions different than the same LNFB training protocol in normal participants, namely, BA 9 and 10 in left medial anterior regions, BA 6 in right frontal regions and BA 19, 7 and 40 in occipital regions. Discernible differences in ROI patterns will be explored further and presented.

A Comprehensive Review of the Psychological Effects of Brainwave Entrainment

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Objective

Brainwave entrainment (BWE), which uses rhythmic stimuli to alter brainwave frequency and thus brain states, has been investigated and used since the late 1800s. We discuss its potential by presenting a systematic review of the literature from peer-reviewed journals on the psychological effects of brainwave entrainment.

Data Sources

Terms used to describe BWE and psychological outcomes were used to search English language studies from OVID Medline (1950–2007), PsycInfo (1806–2007), and Scopus.

Study Selection

More than 20 studies selected satisfied the following criteria: studies needed to use rhythmic stimuli with aims of affecting psychological outcomes. Peer-reviewed experimental and quasi-experimental studies were accepted. Case studies and review articles were excluded. Psychological outcomes were measured using standard assessment methods or deemed appropriate by peer review.

Data Extraction

Other clinical measurements, including EEG response, galvanic skin response, or neurotransmitter levels, were not included.

Data Synthesis

Psychological outcomes addressed cognition, stress and anxiety, pain relief, headaches or migraines, mood, behavior, and premenstrual syndrome (PMS). Protocols included the use of single, alternating, ascending or descending frequencies, or were determined by the subject, using auditory and/or photic stimulation. Studies examined single session effects and/or longer term multiple session effects.

Conclusions

Findings to date suggest that BWE is an effective therapeutic tool. Persons suffering with cognitive functioning deficits, stress, pain, headache/migraines, PMS, and behavior problems benefited from BWE. However, more controlled trials are needed to test additional protocols with outcomes.

Treating Veterans Who Suffer from Fibromyalgia

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Fibromyalgia syndrome (FMS) is a controversial diagnosis in the medical community. The American College of Rheumatology has defined FMS as the presence of widespread musculoskeletal pain with 11 out of 18 positive tender points.

Comorbid depression, anxiety and stress-related disorders, fatigue, muscle stiffness, sleep disturbance, and cognitive fogging are commonly reported. The etiology and pathophysiology remain unclear, although there is general agreement that FMS is a disorder of aberrant central pain processing. Although Pregabalin has recently been approved by the FDA for its treatment, there are no universally accepted treatment algorithms. There is some evidence that several nonpharmacological interventions alone, or in combination, may be efficacious and these include relaxation training using EMG biofeedback, meditation-based stress reduction, cognitive behavioral treatment, education, and physical therapy. More recently, research by Afton showed that heart rate variability (HRV) biofeedback may be a useful treatment for FMS, perhaps mediated by autonomic changes.

The proposed presentation (a) provides a current review of the research on FM, (b) discusses the different theories and conceptual framework for understanding this disorder, (c) presents the intervention efficacy data published to date, and (d) describes the preliminary findings of outcome from our FM Program at the Houston VA Medical Center. In brief, this program combines weekly education and support groups with a nonpharmacological modality (HRV biofeedback, cranial electrotherapy stimulation, or audiovisual stimulation). Progress is monitored using HRV spectral analysis and a packet of psychometric instruments. Preliminary outcome data, based on 6 participants, indicate that although the SDNN (a standard measure of HRV) did not show a statistically significant increase because of the very small sample size of 3 (the others did not have their post-HRV measures completed at the time of this write-up), the effect size was large (0.85). Similarly, the effect sizes for several major symptoms of FM did show substantial improvement (sleep, as measured by the Pittsburg, was large: 0.70; depression, as measured by the Center for Epidemiologic Studies Short Depression Scale, was moderate: 0.45; overall mood states, as measured by the Profile of Mood States, was also moderate: 0.51; decrease in fatigue was statistically significant with a moderate effect size of 0.59; decrease in tension/anxiety was statistically highly significant with a large effect size of 0.85).

In addition to symptom reduction, participants also showed increased use of adaptive and more positive beliefs and coping strategies. For instance, the effect sizes for adapting constructive beliefs and attitudes toward pain range from a small effect of 0.23 to a large effect of 0.81. Finally, the use of catastrophizing, as measured by the Sullivan scale, showed a near significant reduction (with a moderate effect size of 0.52) and an increase in the use of time contingent versus pain contingent coping (effect size of 0.37). The presentation concludes with a discussion of the limitations and implications of the preliminary results.

Paradigms Lost: Intellectual Survival After Expulsion from the Operant Garden with LENS

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What is the relationship between the observed EEG signal and our observable effect on that signal using brain wave biofeedback? In standard EEG neurofeedback we influence the EEG signal by contingent reinforcement of EEG variables, but such changes in the EEG signal tend to be transient, whereas systemic changes in behavior (and presumably in the brain) are long-standing. The operant conditioning model is insufficient to explain efficacy and efficiency of EEG neurofeedback.

This presentation reviews other models which make it clear that new paradigms will emerge to account for our clinical success with neurofeedback. Othmer's regulatory challenge/exercise model is one, Pribram's holonomic digital signal processing model is another. Ochs's LENS demands an entirely different set of paradigms to draw upon if we are to find a model that satisfies us. Cranial nerve stimulation may be one example. Also FA Popp's biophotonic model appears to underpin an entirely new paradigm of intercellular communication

allowing us to glimpse a possible integration of the biophotonic model and the holonomic digital signal processing models. Conceptually, applications of field dynamics from biophysics represent an emerging paradigm shift, but the scientifically contaminated term "energy medicine" may obscure our vision for a while.

At the heart of all neurofeedback paradigmatic explanations are the "smart cookie" and "vanity" models. Beyond the various psychobiological mechanisms that allow the creature within to operate, we are dealing with an imagined higher order entity that we call the brain, which is intelligently trainable because it is drawn to look at itself.

Successful LENS Treatment of Obsessive-Compulsive Disorder

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The only two previous publications on the use of neurofeedback with obsessive-compulsive disorder (OCD) found that approximately 60 neurofeedback sessions were required for a successful outcome. This paper presents details of the treatment of an OCD patient using the Low Energy Neurofeedback System (LENS). An objective and the most thorough measure of OCD, the Yale-Brown Obsessive Compulsive Scale, was administered pre- and posttreatment. In addition, subjective ratings of symptoms were obtained weekly, and external verification of changes obtained through two relatives. After only 30 sessions, the patient was symptom free and had withdrawn from two medications. Five further reinforcement sessions were conducted and follow-ups obtained with both the patient and a relative. The outcome of two more recent OCD cases treated with LENS and using the same outcome measures are also briefly reported.

It must be emphasized that this is an initial report of a case series utilizing LENS treatment for OCD. Thus, although still considered experimental, these encouraging results are supportive of published articles that have found LENS treatment effective with other conditions and suggest that LENS treatment might also produce results more rapidly than traditional neurofeedback.

Autobiographical Memory: Neural Correlates of Experience and Self-in-Experience

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Introduction

This study examines correlations between scores obtained on a recently developed self-perception and experiential schemata assessment and neurophysiological activation patterns according to life area, childhood, adolescence and adulthood utilizing standardized low-resolution electromagnetic tomography (sLORETA).

Methods

This study was accomplished with 27 nonclinical undergraduate students. The participants in this study completed the Self Perception and Experiential Schemata Assessment while undergoing EEG recording. Responses were marked within the EEG record, extrapolated, and compared to baseline for significance. The responses for each subsection were entered into correlation analysis with the sLORETA activation maps.

Results

The data reveal correlations for the obtained scores in each life area show significantly different activity patterns for each life area in each frequency domain.

Discussion

Evaluation of childhood, adolescence, and adulthood correlate with regions shown active during episodic and self-referential autobiographic memory. Each domain of

experience appears to be functionally related to different neuronal circuitry. It is possible that dendritic sources of more remote memories are pruned away over time except in cases of extreme emotional content or reconstructed memory. We discuss implications for both memory trace theory and the standard consolidation model (SCM); moreover, the data appear to favor the SCM, as the hippocampus does not show positive associations with any of the experiential domains; however, there are numerous tasks involved in this study which upon further investigation may offer insight into functional specificity.

Quantitative Electroencephalograph Effects as a Result of Single Session Respiratory Sinus Arrhythmia Feedback in an Anxiety Population

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Objective

Previous investigations of electroencephalographs (EEGs) during relaxation has identified increases in slow wave (theta and alpha) band power, correlations between increased levels of alpha activity with lower levels of anxiety, and autonomic changes characterized by decreased sympathetic activity. This study was carried out to determine the impact of a respiratory sinus arrhythmia (RSA) biofeedback device on quantitative EEG (QEEG).

Methods

Participants were 43 individuals reporting stress levels at least 1 standard deviation above the mean on the Perceived Stress Inventory who were randomly assigned into either a control (concentration device) or experimental group (RSA biofeedback: StressEraser). Participants in both groups were novices given a 15-min training on how to use the devices. The study recorded 19-channel EEG under baseline, stressor task, intervention, postbaseline, and repeated stressor conditions. For each group QEEG analyses were computed.

Results

Ratios of alpha/beta and to a lesser degree theta/beta increased to a significant level in sites O1 and O2 following RSA feedback. QEEG features of power and relative power exhibited trends worthy of future investigation in a larger sample. There were no significant differences in the concentration only control device group.

Conclusions

These findings suggest that RSA feedback may decrease arousal in areas critical to the experience of stress and anxiety and provides physiological evidence of changes produced by RSA feedback.

Progress of Neurofeedback: From Scientific Research to Clinical Application

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There is a significant gap between scientific research and clinical applications of neurofeedback. This gap must be reduced to contribute to the progress of empirically supported treatments and gain credibility from medical and institutional instances in Mexico and worldwide. To understand and face this challenge, we review the methodological difficulties related to scientific research in the field and the importance of overcoming these obstacles.

Not only does the clinical application of neurofeedback require an individual psychophysiological assessment to support protocol decision making, its success relies on many important variables such as the patient's confidence and bond with the therapist.

However, reliable research to prove both neurofeedback's efficacy and specificity involves an empirical control of these variables. Finally, it would be interesting to make the most of a clinical setting planning multicenter research protocols, establishing common goals and methodology, to enlarge evidence-based applications of neurofeedback.

Executive Functions: A New Approach

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Although there is growing evidence for the efficacy of neurofeedback training, there is still some skepticism because of the methodological issues in studies published so far and the doubt of how this method might operate changes in EEG and clinical symptomatology. This lecture examines the executive functions (EF) and correlates the neuroanatomy of the prefrontal region, to these abilities. This knowledge will help us to develop better models to treat conditions where the EF are affected. An open discussion for surface targets and or methods for neurofeedback training is expected by the speaker.

How Modulating Hemispheric Specialization and Interhemispheric Interaction Enable Skilled behavior

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Hemispheric specialization for higher cognitive function in the human brain permits the acquisition and maintenance of highly skilled performance. There is a special role for the right hemisphere in the initial stages of skill acquisition, where conceptual labels are missing or tentative. As the conceptual structure of the domain becomes more elaborate, the analytic role of the left hemisphere becomes more dominant. Further, skilled behavior is made possible by different modes of hemispheric interaction. One mode is the specialization by one hemisphere for efficient processing in a particular cognitive domain. For example, the left hemisphere is specialized for phonetic perception and the right hemisphere is specialized for emotional prosody during auditory language comprehension. A second mode is parallel processing in the two hemispheres when the task is complex and the cognitive domain is within the repertoire of both sides. In that case, shielding the hemispheres from each other is beneficial. A third mode is error monitoring by one side of performance in the other. An example is left hemisphere specialization for visual word recognition (reading) but right hemisphere specialization for detecting errors in reading. These modes are made possible by selective activation and deactivation of one hemisphere or of different channels of the corpus callosum. Those channels therefore provide a target for EEG biofeedback as a means of achieving skilled behavior.

Effect of Psychoneurotherapy Upon Brain Electromagnetic Tomography in Individuals with Major Depressive Disorder

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Context

Recent advances in quantitative electroencephalography (QEEG) and brain computer interface (BCI) technology provide unique and powerful tools that may significantly contribute to the development of psychoneurotherapies.

Objective

The main goal of this study was to test the effect of a QEEG-guided psychoneurotherapy (PNT) upon brain electromagnetic tomography in individuals with major depressive disorder (MDD). The central objective of this treatment was to teach depressed patients to change their negative thoughts and emotions while learning to modify the underlying brain activity through a BCI. We predicted that the treatment would significantly reduce depressive symptoms and QEEG abnormalities.

Methods

Twenty-seven participants (22 female and 5 male; age range = 27–58) participated in this study. The severity of depressive symptoms was assessed by the Beck Depression Inventory–Second Edition (BDI–II). EEG was recorded (Deymed Diagnostic, TruScan 32) before and approximately 1 month after the PNT from 19 scalp locations. Based on the results of spectral analyses, participants were taught during the PNT to modify their negative thoughts and emotional states while learning to reduce high-beta (18–30 Hz) activity in right fronto-temporal/paralimbic regions. Participants met the therapist two times per week for twenty 1-hr sessions. Brain changes were measured through standardized low resolution brain electromagnetic tomography (sLORETA).

Results

Following treatment, there was a significant reduction of BDI-II scores ($p < .001$), and 20 out of 27 (74%) participants did not meet the *DSM–IV* criteria for MDD. In addition, absolute power of high-beta (18–30 Hz) activity showed a significant reduction in the right lateral prefrontal cortex, right orbitofrontal cortex, right insula, right subgenual cingulate cortex, and right anterior temporal pole. It is noteworthy that these brain regions play a key role in executive functions, emotion, or emotional self-regulation.

Conclusions

These findings suggest that the proposed PNT used in this study can significantly improve brain activity and reduce depressive symptoms in individuals with MDD.

Efficacy of Neurofeedback for Executive and Memory Function in Dementia: Preliminary Findings

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Introduction

Previous studies have shown that dementia is associated with reduced cerebral blood flow (CBF) and various quantitative EEG (QEEG) abnormalities including a reduction in the dominant alpha frequency. The purpose of this study is to test whether neurofeedback training to normalize abnormal EEG rhythms and increase CBF can improve measures of memory and executive function.

Methods

Twelve participants are currently enrolled, where half are randomly assigned to a waiting list control condition. All participants receive a comprehensive assessment of memory and executive function, and a QEEG assessment. Thirty sessions of QEEG-guided neurofeedback are administered, where a random half of participants also receive frontal CBF biofeedback during their sessions.

Results

Two treatment group participants and one control have presently completed the study. Compared to the control case, the treated cases showed improvements, ranging from modest to dramatic, in the Integrated Visual and Auditory Continuous Performance Test (attention and response control), the Rey Complex Figure (nonverbal recall), Memory Assessment System List Acquisition (verbal working memory), the Behavior Rating Inventory of Executive Function-Adult Version (executive symptom self-report), and the Delis-Kaplan Executive Function System (DKEFS) Verbal and Design Fluency, and Letter-Number Sequencing.

Discussion

These results should be interpreted cautiously because of low participant number. For example, neurofeedback appeared to worsen performance on the Wisconsin Card Sort and DKEFS Word Context tests. Six

additional participants are expected to complete posttesting in time for this presentation.

Personalized Pharmaco-EEG: Predicting Medication Responses

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This presentation reviews recent research in quantitative EEG and how it is predicting psychotropic medication responses. The results of the BRITE study by Aspect Medical are reviewed along with the research on Referenced-EEG by central nervous system response. Clinical examples of how it is used, particularly in treatment resistant patients, are presented.

Hypermobility Syndrome—An Ideal Candidate for Neurofeedback

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Introduction

Hypermobility Syndromes are genetic disorders where connective tissue abnormalities cause flexible joints which lead to injury and pain. Autonomic Nervous System dysfunction is a frequent comorbidity. Children with this disorder tend to also experience dyslexia, dyscalculia, and dyspraxia.

Methods and Results

Quantitative EEG findings on children with Hypermobility Syndrome are presented. A detailed single case study is outlined. The approaches used involved both neurofeedback and HRV biofeedback.

Conclusions

It was found that neurofeedback and HRV biofeedback were effective in reducing levels of pain and led to improved concentration and academic performance.

The Effect of the Low Energy Neurofeedback System on Children with ADHD

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The purpose of this study was to examine the effect of the Low Energy Neurofeedback System (LENS) on children who have been diagnosed with Attention Deficit Hyperactivity/Impulsivity Disorder (ADHD). In this study 10 children who had been diagnosed with ADHD were given 15 sessions of LENS treatment. The J&J C2 Plus 12 was utilized as the EEG Neurofeedback device giving LENS stimulations.

The study began with all the children receiving a LENS map as a pretest baseline. After baseline data were collected, the children were given one session per week for 15 weeks. All the children were given the same LENS protocols so that the amount of LENS stimulation given was the same for all research participants. After the 15-week treatment period was complete the children were given another LENS Map posttest. All participants were tested pre- and posttest with the Integrated Visual Auditory Continuous Performance Task (IVA-CPT) on the same days in which they received pre and post LENS Maps. The parents of each child were asked to complete the Conners' Parent Rating Scale short form. Pre- and post-CRS–S where given to parents prior to and following all LENS Maps. Several one way analyses of variance were run on the data using SPSS for Windows. The data show significant differences between pre- and posttest EEG LENS Maps, IVA-CPT scores and CRS–S ratings. The data suggest that the LENS is an effective treatment for children who have been diagnosed with ADHD.

Reading Difference Topography as an Aid to Neurofeedback Remediation of Reading Difficulty

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Reading difference topography is a quantitative EEG (QEEG) technique that we have used in more than 150 participants as an aid to understanding the disturbed cortical physiology underlying reading difficulty. Typically there are increases in focal slowing over critical reading areas when the person reads. There are often decreases in coherence (connectivity) between those areas and other critical reading areas. When these abnormalities are normalized with neurofeedback done while the patient reads, their reading ability usually improves. There may be abnormalities in the eyes-open condition (not reading) that need to be normalized. Case histories are presented illustrating the types of abnormalities found.

Efficacy of Connectivity Guided Neurofeedback for Autistic Spectrum Disorder: Controlled Analysis of 75 Cases with a 1- to 2-Year Follow-Up

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Introduction

Autistic disorders have multisystem impact with significant adverse effects on the development of the central nervous system. The neurobiological study of autistic disorders has shown problems related to neural connectivity. This has been demonstrated at multiple levels of analyses including neuropathological, fMRI, MRI-DTI, and EEG studies. As such, therapeutic interventions of significance should lead to improvements in neural connectivity. We have shown that specific connectivity guided EEG training approaches (a) are effective in reducing autistic symptoms, (b) lead to therapeutic changes on measures of EEG connectivity and power, and (c) these changes are localizable and predictable. However, studies have had relatively small sample sizes, we examined the effects of segments of treatment only, and there has never been a follow-up period without treatment to measure the persistence of these effects.

Method

One hundred children with a diagnosis of Autistic Spectrum Disorder were included, 75 in the experimental group and 25 composed a wait list control group. The experimental group received quantitative EEG (QEEG) connectivity guided neurofeedback for at least 35 sessions. Pre- and post-QEEG, neuropsychological, educational, and parent rating scale measures were used to measure outcome. In addition, 20 patients from the experimental group were reassessed 1 to 2 years following the completion of their treatment with the same measures to assess the persistence of the effects of treatment.

Results

Findings show significant reduction in autistic symptoms, improvement on neuropsychological and educational measures, and reduction in QEEG abnormalities, all at $p < .01$, when compared to the waitlist control group. Analysis of the follow-up sample showed no regression as compared to when they completed their treatment.

Conclusions

In the largest controlled study of neurofeedback for autistic spectrum disorder, the data suggest significant improvements and persistence of these effects even after treatment has stopped. The implications of these findings are discussed.

Noninvasive Brain Stimulation as a Neuromodulatory Approach: Review on the Clinical and Neurophysiological Effects

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In neurology and psychiatry, like in all of medicine, symptoms of disease and the resulting burden of illness and disability are not simply the consequence of the injury, inflammation, or dysfunction of a given organ. Instead they are ultimately the

consequences of the nervous system's attempt to adapt to the insult. This plastic response includes compensatory changes that prove adaptive for the individual, as well as changes that contribute to functional disability and are thus maladaptive. In this context brain stimulation techniques tailored to guide individual plastic changes associated with neurological and psychiatric diseases might enhance clinical benefits and minimize adverse effects. For this lecture, I discuss the application of two noninvasive brain stimulation techniques—repetitive transcranial magnetic stimulation and transcranial direct current stimulation—to modulate activity in the targeted cortex or in a dysfunctional network, restore an adaptive equilibrium in a disrupted network for best behavioral outcome, and suppress plastic changes for functional advantage. I therefore review the mechanisms of these two techniques of noninvasive brain stimulation and their potential clinical utility in psychiatry and neurology.

Time-Frequency Components of Brain Connectivity: Methods and Examples

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Measures of linear dependence (coherence) and nonlinear dependence (phase synchronization) between any number of multivariate time series are defined. The measures are expressed as the sum of lagged dependence and instantaneous dependence. The measures are nonnegative and take the value zero only when there is independence of the pertinent type. These measures are defined in the frequency domain and are applicable to stationary and nonstationary time series. One important field of application is neurophysiology, where the time series consist of electric neuronal activity at several brain locations. Coherence and phase synchronization are interpreted as "connectivity" between locations. However, any measure of dependence is highly contaminated with an instantaneous, nonphysiological contribution because of volume conduction and low spatial resolution. The new techniques remove this confounding factor considerably. Moreover, the measures of dependence can be applied to any number of brain areas jointly, that is, distributed cortical networks, whose activity can be estimated with eLORETA (exact low resolution brain electromagnetic tomography). A time-frequency analysis of single-trial ERP data during word processing is presented.

Expanded Study and 1 Year Follow-Up of Treating Early Dementia with Low Energy Neurofeedback System

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Background

Examining cases of dementia of the Alzheimer's type, a pilot study was undertaken that revealed extensive posterior slowing (delta and theta) that progresses around the left temporal area. In addition, there were a significant number of amplitude asymmetries and significant coherence abnormalities found. The Low Energy Neurofeedback System (LENS) specifically attempts to lower high-amplitude low frequencies. Therefore, the LENS system was applied to patients who had the characteristic posterior high amplitude lower frequencies with corresponding amplitude asymmetries and coherence abnormalities to examine what effect the treatment method would have on deteriorating memory.

Method

Quantitative EEGs (QEEGs) were done before and after LENS treatment in patients who presented with deteriorating memory and posterior slowing with amplitude asymmetries and coherence abnormalities. LENS treatments were administered with periodic LENS maps. After the LENS treatments were completed, a post-QEEG was done to determine the effects the LENS treatment may have had on the characteristic slowing and abnormalities originally presented in the patient.

Results

Patients reported improvements in their memories as subjectively determined by job performance and as reported by the patients' family members for cases that had early signs of the characteristic slowing and abnormalities. More advance cases did not respond with memory improvements but some cognitive improvements were noted.

Discussion and Conclusion

There seems to be a limit as to when the LENS system can be applied successfully to reduce the deterioration of memory. Further investigation of successful LENS treatment for memory decline was done 15 months after the LENS treatment was completed. Memory functioning seems to remain strong, and the follow-up QEEG is presented.

Intelligence and EEG Phase Reset: A Two-Compartmental Model of Phase Shift and Lock

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Objectives

EEG phase reset involves a brief phase shift followed by phase synchrony and is the foundation of coherence and coupling between brain regions. The purpose of this study was to explore the relationship between EEG phase reset and Intelligence.

Methods

The EEG was recorded from 19 scalp locations from 378 participants ranging in age from 5 years to 17.6 years. The Wechsler Intelligence Test was administered to the same participants on the same day but not while the EEG was recorded. Complex demodulation was used to compute instantaneous EEG phase reset and phase shift duration and phase lock duration.

Results

Phase shift duration (40–90 ms) was positively related to intelligence ($p < .00001$) and the phase lock duration (100–800 ms) was negatively related to intelligence ($p < .00001$) Phase reset in short interelectrode distances (6 cm) was more highly correlated to IQ ($p < .0001$) than in long distances (>12 cm).

Conclusions

Information processing occurs primarily in local regions of the brain and less in the long distant systems. EEG phase reset reflects neural resource identification and allocation. A two compartmental model of local field coupling and neuron synchrony to a preferred phase of local field potentials was developed to explain the findings. It is hypothesized that inhibitory neurons rapidly shift frequency and that iteration in excitatory loops determines phase lock duration, which is directly related to the magnitude of EEG coherence. The larger the number of neurons synchronized at each moment of time then the higher is performance on an IQ test. The duration of unstable phase dynamics and stable phase locking represent a bounded optimization process, for example, a too long duration of phase locking then less flexibility and a too-short phase shift then reduced neural resources.

Comodulation and Coherence: Models of Magnitude and Phase Synchrony

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Introduction

Confusion about the concepts of coherence and comodulation has hindered their simultaneous use in assessing EEG synchrony. Coherence and comodulation are models of phase synchrony and magnitude synchrony, respectively, spectral network properties that occupy distinct but adjacent cells on a proposed periodicity table. Child

and adult EEG data were analyzed for coherence and comodulation in order to differentiate these properties empirically.

Method

Eyes-closed resting EEG was acquired and spectrally analyzed for 101 children and adults between ages of 5 and 35 years (34 female, 67 male; M age = 17.5 years). Analysis focused on site connectivity of 10 frequency bands. Site connectivity refers to total coherence or comodulation associated with a site divided by number of contributing site-pairs.

Results

Posterior site coherence and comodulation both increased with age for frequencies below 30 Hz ($p < .0001$). Anterior site comodulation also increased with age ($p < .0001$). Maximum site coherence progressed anteriorly with age for alpha and sensorimotor response bands ($p < .001$), but no similar topographic pattern was found for site comodulation. Alpha comodulation at electrode site T5 exhibited the strongest age function ($r = .75$, $p < .0001$).

Discussion

Functional connectivity is a central principle of brain maturation. Site coherence and comodulation of low and moderate frequencies were found to increase with age at most sites and may be useful in evaluating regional differences in brain maturity. A model that associates coherence with feedforward activity and comodulation with feedback activity of the brain is proposed.

The Basic Application of Pharmaco-EEG in a Clinical Setting

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Pharmaco-EEG is a noninvasive method to help guide the choice of psychotropic drug treatment. Although Pharmaco-EEG was started in the 1960s, its application in psychiatry has, for the most part, been limited to research and has never made it into clinical practice. However, we have found that every quantitative EEG (qEEG) provides valuable information that a psychiatrist should be made aware. This presentation provides basic examples of the challenges and rewards of using qEEG data to help guide psychotropic drug treatment.

Neurofeedback and Motivational Interviewing Based Bio-Behavioral Treatment in Cocaine Addiction

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Introduction

Cocaine dependence is one of the most severe addictions associated with significant morbidity and mortality. Cocaine addicts are very difficult-to-treat population being featured by a low motivation to change their drug habit and are reluctant to enter inpatient treatment (Crits-Christoph et al., 1997). Motivational interviewing (MI) is a brief psychotherapeutic intervention for behavioral change aimed to bring about rapid commitment to change addictive behaviors. Because of its brevity, MI is best suited to enhance compliance and facilitate treatment engagement (Stotts et al., 2006). Neurofeedback training-based neurotherapy is one of the potentially efficacious nonpharmacological treatment options for cocaine addiction (Sokhadze et al., 2008). EEG changes in beta and theta power are typical for withdrawal from cocaine. Cocaine abusers who are still taking drug often present excess amount of both low- and high-frequency EEG activity (Prichep et al., 2002). Thus cocaine users may benefit from EEG biofeedback protocol aimed on increasing sensorimotor response (SMR) (12–15 Hz) and decreasing theta (4–8 Hz) activity at the vertex that is commonly used in the treatment of attention deficit

hyperactivity disorder (Monastra et al., 2005). We proposed that a combined application of neurofeedback and motivational interviewing techniques will result in an effective biobehavioral intervention for cocaine addiction.

Method

Cognitive, behavioral, and emotional deficits and level of their persistence in cocaine users undergoing behavioral treatment based on neurofeedback and motivational interviewing (MI) were explored in this study on 14 cocaine-dependent outpatient participants. Dense-array event-related potential (ERP) were assessed prior and following bio-behavioral intervention using cognitive tasks containing drug-related and generally affective cues, and during cognitive tasks aimed to test cortical inhibitory capacity, selective attention, and cortical functional connectivity. The study examined cue reactivity to drug-related stimuli (three-stimuli oddball task with pictorial and verbal stimuli) and executive functions (e.g., cortical inhibition in Go-NoGo task, error monitoring in Eriksen flanker task, etc.) assessed during behavioral tests with ERP recording before and after 4-week long behavioral treatments. Along with behavioral and ERP measures during tests and IVA + Plus test results, the treatment outcomes included cocaine use rate (urine and saliva screens), maintaining treatment retention, intent-to-treat, and psychiatric status (posttraumatic stress disorder, depression symptoms). Most participants tested positive both on cocaine and marijuana use on the intake stage. Each participant took part in 12 sessions of SMR up/Theta down training (30 min, twice a week) and up to 3 sessions of MI. The neurofeedback session included blocks with "SMR increase," "SMR increase and Theta decrease," and "SMR/Theta" ratio increase.

Results

Most of the participants successfully learned to increase SMR rhythm but were less successful in simultaneous SMR increase and Theta decrease blocks. Increase of the SMR during successful neurofeedback sessions was accompanied by a general arousal increase as indexed by the parallel increase of low and high beta band power as well as a significant increase of the skin conductance level and the number of non-specific skin conductance response frequency and skin temperature decrease. Participants who completed whole course of combined neurofeedback and MI intervention showed improvement on behavioral and ERP measures of selective attention and other executive functions and showed decreased reactivity to drug-related cues. Among the clinical outcome measures the most significant was decrease of depression scores (Beck Depression Inventory). The drug screens did not show decrease in cocaine use, however, the number of positive tests for marijuana use decreased significantly.

Conclusion

MI happened to be a very useful in maintaining high level of the intent-to-treat and retention in this study. The results of this pilot study support the suggestion that a combination of MI with neurofeedback might be a promising approach to biobehavioral intervention for addictive disorders, and specifically for treatment of cocaine addiction in outpatient population.

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EEG Bispectral Analysis: Applications in Monitoring Conscious Awareness, Medication Management, and Tracking Effectiveness of Treatment in Dementia

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EEG bispectral analysis is an advanced signal processing technique that can be used to assess coherence among different EEG frequencies. This method has been developed into an index of depth of anesthesia (BIS) and is widely used to monitor for conscious awareness during surgery. Research recently published in the *New England Journal of Medicine* comparing BIS to analysis of exhaled anesthetic is reviewed and critiqued. New results from a multicenter clinical research trial using EEG monitoring to manage administration of antidepressant medication are presented, and new data on using a new derivation of BIS, termed BIS–D, used to detect and monitor dementing illness are reviewed.

Clinical Outcomes in Addiction: A Large Neurofeedback Case Series

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Introduction

Addiction is a serious public health problem that has historically had low levels of success, though anecdotal reports of improvements following NF treatments are reported. The initial characterization of the EEG/qEEG baseline phenotypes in addiction characterizes the underlying physiopathology in addiction, with phenotypes indicating both overarousal and cingulated disturbance loading very strongly into this clinical group. The results of NF treatments guided by the qEEG phenotypes will be evaluated with pre-post neuropsychiatric measures.

Method

The first 30 clients to complete the program were analyzed. Pre-post quantitative EEGs, as well as testing for IQ, thinking ability, cognitive efficiency, audio-visual learning ability, delayed recall, working memory, and sobriety/abstinence were collected and analyzed to evaluate the impact of NF and treatments on the clients performance on the various testing.

Results

The pre–post outcomes are graphed with overlying normative distributions for reference. The pre–post comparisons are used to highlight the improved overall cognitive effects experienced clinically by those finishing the phenotype-driven NF and therapeutic regimen.

Discussion

The dramatic improvement in IQ, memory, and other factors are demonstrated in this group of addiction clients. The incidence of two phenotypical divergence patterns in the addiction population is noted and suggests two very different approaches. The overarousal factor drives one subset of clients in addiction, and the cingulate based phenotypical divergence pattern drives the other. The use of the phenotype rather than the behavioral diagnosis helps select the appropriate intervention, thus allowing the dramatic improvement seen in these clinical outcomes.

Neurological Aspects of the Tomatis Audio-Psycho-Phonology (APP) as Deduced from QEEG Brain Mapping and Auditory Evoked Potentials (AEP)

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Introduction

The sounds provided in the Tomatis APP Listening therapy cause neurophysiological stimulation. The physiological stimulation is due to the movements of the ossicles and of the membranes, that is, the eardrum and the oval and circular membranes, and thereby training the antagonistic muscles of the middle ear. The neurological stimulation besides the brain concerns also the hearing, the equilibrium, the vagus nerve, and the recurrent nerves. The recurrent nerve for the left ear has a longer pathway to the larynx than for the right ear, which, combined with the localization of the Broca motor center of speech only in the left hemisphere, results in a retardation of speech by about 0.03 s when the feedback is dominated by the left ear (Tomatis, 1991). This fact and the dominance of the left hemisphere for logics, abstract thinking, language, reading, writing, and calculus stimulated Tomatis to emphasize training of the right ear. The neural stimulation by sound of all organs and muscles of the body is largely accomplished by means of the vagus nerve, which branches from the eardrum and from the outer hearing channel via the spinal marrow to all those peripheries in the body. In general, changes due to the therapy are well visible in the measured QEEG-brain maps and in the auditory evoked potentials (AEPs). They can be correlated with changes in the Listening tests and with the observed improvements in the problems of the individual participants.

In recent years, auditory evoked response techniques have been utilized to objectively assess integrity of the central auditory system in children with learning disabilities, autism, language and attention deficit disorders (Van den Bergh, 1998). Many hundreds of individuals have been treated in this way at the Atlantis Institute. At the conference the method is illustrated by the treatment of a man, called Eugen, who suffered a severe stroke, with lack of speech and bad walking.

Method

Eugen has received the Listening Therapy at the Atlantis Institute over $2\frac{1}{2}$ years, with 424 30-min sessions and eight intermissions of 2 to 9 months. The quantitative electroencephalography (QEEG) and AEP data were taken with the Sirius, ESAOTE BIOMEDICA equipment, along with the Listening tests (audiograms) before, during, and after the Tomatis APP therapy. The QEEG data are processed quantitatively, in contrast to the classical EEG, as to reconstruct a map of responses over the brain surface, called the brain map. AEPs are measured at the Atlantis Institute, with 19 electrodes on the skull using the International System of Electrode Placement. Auditory clicks or tones are presented mostly into the left ear and the measurements are registered (Van den Bergh, 1998). With the cognitive auditory potentials, the mental processing mechanisms of the auditory perception (attention mechanisms) are explored. Wearing the headphones, 150 tones are presented to the participant; 120 of them are frequent, ''standard'' low-pitched and 30 are ''rare,'' high-pitched tones. This test is performed under both the attention (to the rare tones) and nonattention condition. Those cognitive potentials are in many cases disturbed in individuals with cognitive immaturity, attention deficit disorders, and learning disabilities.

Results

Eugen has experienced a significant recovery of his speech and motor system. He only moves somewhat slowly with the right leg. In most other cases learning abilities were improved with better concentration, speech, and communication. Lasting improvements have been reported by several institutes, with an average score of about 80% (see http://www.tomatis.com).

In general our results were verified by other institutes or doctors, as was the case by, for example, the University Clinic at Giessen & Marburg, Germany, where different diagnostic tools were applied, also including EEG measurements. Placebo groups or shams have been followed at several other institutes (see, e.g., http://www.tomatis.com and by Tomatis, 1991).

Those investigations all show clearly net effects of the method.

Conclusions

It can be concluded that the Listening tests are replicated by the QEEG-brain-map data, thus independently correlating the results of those tests. In most cases attention and concentration problems were observed during the Listening test by the high and often descending bone conduction results at low frequencies with respect to the air conduction test results. This correlated strongly with large δ activity frontal and prefrontal and with the absence or weak α activity, mostly occipital, in the corresponding brain maps and with weak N200 and P300 amplitudes in the oddball paradigm AEPs, both indicating little alertness. After the Listening therapy those aspects were improved in the Listening tests, as well as in the brain maps and AEPs. Generally a correlation was also observed in the case of language disorders between the diminished sensitivity in the middle frequency region of about 1000–3000 Hz in the Listening tests and the diminished activity at the temporal lobes in the brain maps. Therefore Listening tests can be used as reliable evidence to support the results of the Listening therapy as they are replicated by the QEEG data. It may be noticed that several neurological aspects of the Tomatis method are similar to those of the Neurofeedback.

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Developmental Changes in the EEG of People with ADHD: Results from an Initial Investigation

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Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the most common disorders of childhood, and research is finding that as many as 60% of childhood sufferers will continue to have the disorder as adults. Research has further shown that the symptom profile of people with ADHD continues to change as they get older, with the hyperactivity commonly seen in childhood reducing, but the impulsive and inattentive components remaining. In addition to the maturational changes in the core symptoms, the profile of other comorbid problems also changes. The aim of this study was to investigate changes in the EEG from childhood to adulthood.

Methods

Forty participants were initially assessed as children (8–12 years old) and reassessed as adults (22–26 years old), with a clinical interview being performed and an eyes-closed resting EEG being recorded at both assessments. From these assessments, EEG abnormalities in the adult population, and changes in the EEG profiles from child to adult were evaluated.

Results

The results indicated the existence of some EEG power and coherence abnormalities in children with ADHD which continued into adulthood. Differences in the EEG were also evident between those that outgrew the disorder and those that continued to be symptomatic into adulthood.

Discussion

These results have important implications for our understanding of developmental changes in the disorder, which are discussed in this presentation.

Comparison of the TOVA and IVA in a Clinical Population

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The intake TOVAs and IVAs of 300 clients at an attention deficit hyperactivity disorder (ADHD) clinic were compared to each other and to other intake data (parent and/or self report) to determine the diagnostic strengths and weaknesses of each test. Where ADHD or a related disorder was the focus of treatment, the intake was classified as belonging to one of the following categories, according to presenting problems and client checklists: anxiety, ADHD inattentive type, ADHD Impulsive or Combined Type, oppositional defiant disorder, or Asperger's disorder. The correlations of the TOVA (Visual form) and IVA with client checklists and intake concerns were compared, and the efficiency of the TOVA and IVA in differentiating the diagnostic groups was investigated.

The TOVA was found to be better than the IVA in correctly identifying deviations from the norm for all groups. It was superior to the IVA in identifying inattention, whereas both tests were effective measures for impulsivity. The TOVA showed higher correlations with client checklists than the IVA. Further analysis of the IVA subtests suggests that the stamina variable does not contribute significantly to differentiation of ADHD subtypes. The constancy and focus variables are so highly correlated in this sample, that there is a question about the utility of having one contribute to the response control variable, whereas the other contributes to the attention variable. Analysis of TOVA variables suggests that anxiety and ADHD impulsive/combined type share a common profile. ADHD Inattentive type, oppositional defiant disorder, and Asperger's disorder also share a similar profile.

Endophenotypes of ADHD in Children and Adults

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Prevalence of ADHD

Attention deficit hyperactivity disorder (ADHD) represents a psychiatric disorder with a high estimated three to five percent in school-age children (*DSM–IV*). Approximately one half of these children continue to manifest ADHD-associated symptoms in adulthood (Biederman, 2005). In the United States the following prevalences in adults with ADHD are known: 4.7% (Murphy & Barkley, 1996), 4.5% (DuPaul et al., 1997), 4.0% (Heiligenstein et al., 1997). In Switzerland, the estimation ranges from 2% to 4% (Eich, 2006).

Symptoms

The most prominent symptoms are not only attention deficits but also difficulties in executive functions, mostly in impulse control/inhibition and working memory. In addition, an emotional dysregulation is often found. ADHD has been described from many perspectives. I am going to circumscribe only the neurophysiological findings.

Models

There are different explanation models for ADHD. The two most common models are the Maturational Lag Model of ADHD (Kinsbourne, 1973) and the Developmental Deviation Model of ADHD (Chabot & Serfontein, 1996; Clarke et al., 2001d). The first model assumes that children with ADHD show a delay in maturation of the central nervous system. That means they have not yet reached the appropriate

developmental stage according to their age. Their EEGs would be considered normal in younger children. The second model assumes the symptomatology of ADHD to have its origin in a dysfunction of the central nervous system. The EEGs of these children is considered to be abnormal at any age. Another model that can be subsumed under the Developmental Deviation Model of ADHD is the Hypoarousal Model of ADHD (Satterfield, Cantwell, & Satterfield, 1974). This model assumes that the ADHD symptoms are caused by an underactivation of the cortex.

Both the Maturational Lag Model of ADHD and the Developmental Deviation Model of ADHD are not sufficient to explain the symptoms of this disorder. The often-seen fact that hyperactivity of ADHD children diminishes with aging and the reduced beta activity normalizes is in line with the first model, whereas attention deficits and increased theta activity, which can also be found in adults could be explained by the second model. Both models are therefore too simplifying and are not able to explain the very complex processes in ADHD. It is necessary to develop new models.

Eeg-Defined Subtypes: A Multicenter Study

In a wide-organized study across Europe in the frame of Cost B27 an action of the EU (Participation: Norway, Germany, Austria, Italy, Macedonia, Turkey, Switzerland) it will be shown that QEEG and especially ERP combined with new HBI-Database and sLORETA are very good tools for making a contribution to ADHD-endophaenotypes. The neurophysiological tools are combined with neuropsychological testing and many questionnaires and interviews. The sample size will be between 250 and 350 participants from 18 to 50 years of age. There is no larger study in this field across Europe at this time.

Presentation

The presentation shows first results of the already-studied population. The used neurophysiological model shows that the EEG subtypes in adults are nearly the same as in children, but the frequencies of different subtypes differs enormous. The study shows that ADHD in adults is much more driven by dysfunction of anterior cingulate cortex than from inhibition dysfunction. This explains the wide range of comorbidities in adults. The study aims a more objective diagnoses system and better information for drug-treatment, neuronal stimulation and help in everyday life.

REFERENCE

Satterfield, J. H., Cantwell, D. P., & Satterfield, B. T. (1974). Pathophysiology of the hyperactive child syndrome. *Archives of General Psychiatry*, *31*, 839–44.

ERPs Endopenotypes and Their Application in Neurotherapy

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The presentation reviews recent findings in our laboratory. The first part deals with a methodological approach for assessing brain functions. Theoretical part of this approach is based on our experimental findings of local field potentials and impulse activity of neurons in patients with implanted electrodes as well as on neural net simulations of information processing in the human brain. The theory suggests that the brain is decomposed into basic systems such as sensory, executive, affective, memory systems, and attention networks. Modulation of information flow in each of the systems is characterized by specific rhythms, whereas stages of information processing in these systems are reflected in specific ERP components. Varying tasks and modalities it is feasible to test functioning of practically all cortical areas of the brain. For a particular patient the choice of the task is defined on the patient's complains and on the basis of neuropsychological impairments in the patient.

The second part deals with practical application of the theoretical concepts in a form

the HBI Reference Database. The normative data includes 19-channel EEG recordings in 1,000 people ages 7 to 89 years. It also includes recordings of 400 attention deficit hyperactivity disorder (ADHD) children and adolescents, as well as numerous recordings in other kind of patients (patients with epilepsy, obsessive compulsive disorder, addiction, depression, whiplash, etc.). A 19-channel EEG was recorded in two resting conditions with eyes open, eyes closed, and four different task conditions, including two stimulus GO/NOGO task, arithmetic, reading and two auditory tasks. To reduce amount of time for preprocessing the data several procedures such as artifact correction, artifact elimination, and spike detection are automated. Absolute amplitude and power spectra, averaged and two-channel coherences, wavelet-transformations and event-related potentials (ERPs) are computed in three different montages off-line and mapped into 2D representations or into 3D images using LORETA technology (including s-LORETA). Comparison with the database consists of computing *z* scores—standardized measures of deviation of individual EEG parameters from the normative data. ERPs are subjected to independent component analysis. Using this methodology, separate components associated with distinctive psychological operations are extracted. Each component is characterized by time dynamics, 2D topography, and LORETA image and represents an endophenotype of the brain functioning. Spatial filters are built up on the basis of these topographies and provide the means to extract the amplitude of each component from the individual ERPs. Comparing these amplitudes with the normative data gives the insights concerning different stages of information processing in the individual under assessment.

In the third part of the presentation, the results of application of the HBI database for diagnosis various brain dysfunctions are presented. Finally, the application of the database for constructing protocols of neurofeedback and transcranial Direct Current Stimulation in different brain disorders such as ADHD and stroke patients is presented.

The Respective Roles of Bipolar and of Synchrony Training

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The original research by Sterman and Lubar on human participants was conducted with bipolar placement on the sensorimotor strip. The shift toward quantitative EEG–guided training also involved a shift toward referential placement. Clinical impressions guided a return to bipolar placement over the past several years. The greater strength of that training is attributed to the stronger role of relative phase. The greater strength also motivated a reward-frequency optimization strategy that took us out of the traditional sensorimotor response (SMR)/beta range of frequencies. Data on the distribution of optimum reward frequencies are given on some 250 clients. A common mechanism is postulated for the whole frequency range covered by the clinical data. This is referred to as Resonant Frequency Training in that the responsivity of individuals has the character of a standard resonance curve.

There is a bias in bipolar training toward desynchronization of EEG rhythms. The question was therefore addressed whether synchrony training at the same resonant frequency would have complementary, clinically useful effects. A corresponding frequency optimization strategy disclosed that the synchrony training tended to optimize at the known cortical resting frequencies of alpha in the posterior region, SMR (nominally 14 Hz) in the central region, and theta in the frontal region (nominally 7 Hz).

Both types of training may be understood as an appeal to the brain that lies predominantly in the phase domain. The promotion of phase synchrony tends to favor the standard training bands that have been used in the field to date, whereas the differential training tends to optimize very individually depending on the particular nervous system characteristics.