

SOCIETY OF APPLIED NEUROSCIENCE 2004 ABSTRACTS

EEG STATES BEFORE CORRECT AND INCORRECT TRIALS IN CHILDREN WITH AND WITHOUT ADHD

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Background

Children with Attention Deficit/Hyperactivity Disorder (ADHD) typically show excess theta and reduced beta waves in their EEGs compared to control children, but little is known of the modulation of these parameters as attention fluctuates.

Methods

Data were previous recordings from 13 children with ADHD (never medicated with psycho-stimulants) and 10 controls, all 6-9 years old and having at least 5 errors in the Go/no-Go task. Three analysis techniques, namely spectral amplitude (AMPL), coherence (COH) and a new method called Dominant Phase Amplitude (DPA), were applied to 0.5 s segments just preceding stimulus presentation that were classified into correct or incorrect trials (i.e. adequate or inadequate attention). Permutation tests (Achim, 1995, 2001) with $\alpha = 0.01$ were applied separately by frequency band but collectively to all channels or channel pairs.

Results

Over all 23 children, the EEG preceding correct and incorrect trials differed for the following band-method combinations: 4 Hz-DPA, 12 Hz-AMPL, 14 Hz-AMPL, 14 Hz-COH, 18 Hz-AMPL (amplitude before errors was elevated at 4 Hz and reduced at 14 and 18 Hz). Although these differences tended to be significant in the ADHD group but not in the control group, all corresponding group x condition interactions yielded larger p values than the non significant condition effect within the control group. Looking specifically for group x condition effects, two band-method combinations were identified on which the ADHD children could differ from controls, but their patterns were not convincing (one was clearly due to a single outlier).

Conclusions

The lack of effect in controls could be due to low power, since they typically had much fewer error trials. Finding within-subject effects that parallel previously documented group differences suggests that these EEG markers reflect state rather than trait, but evidence is still lacking whether the inattention of children with ADHD differs qualitatively from that of controls.

THE MIXED GENERAL LINEAR MODEL OF STATISTICAL ANALYSIS APPLIED TO QEEG

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Background

This paper describes the application of the mixed general linear model statistical analysis of the quantitative

information from an electroencephalogram (qEEG). The modeling is similar to regression, which builds a regression or “best-fit” model for the data structure, but, in addition, provides for correlations between observations. A linear mixed model states that data consists of two parts, fixed effects and random effects. Fixed effects determine the expected values of the observations, while random effects account for random deviations from these expected values both between and within individuals. If errors are independent between subjects, deviations from expected values may also be modeled by modeling the covariance structure of residuals. The term ‘repeated measures’ here refers to data with multiple observations from one specific source. It is reasonable to assume that observations from the same individual, are correlated, if only slightly, in some measurable way. Consequently, statistical analysis of repeated measures data gives a more accurate prediction capability when the issue of covariation between these measures is addressed.

Methods

With advances in technology and recently available mixed model methodology, e.g., the mixed procedure (Mixed PROC) of the SAS® system, the covariance structure can more easily be incorporated into the statistical model. In our approach we disregarded potential random effects that would not be specific to single individuals. Thus, by absorbing potential within-subject random effects into the covariance matrix, we can work with the simplified model.

Results

Examples will be presented highlighting differences in information possibly hidden in data structures.

Conclusions

The use of a mixed procedure for modeling data structures provides a more accurate and objective method of analysis and yields quantifiable equations for testing predictions. Essentially, this method allows the physiological pattern of each individual, not related to any other variable, to be represented and accounted for within the model.

FUNCTIONAL CO-ORDINATION IN THE DYSFUNCTIONAL BRAIN: A STUDY OF EEG FUNCTIONAL CONNECTIVITY IN SCHIZOPHRENIA

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Advances in our understanding of the importance of functional specialisation in the neocortex have been accompanied by a growing realisation of the need for mechanisms to co-ordinate activity between different brain regions. Unfortunately, our knowledge about how this co-ordination emerges lags well behind our knowledge of functional specialisation. It seems likely, however, that healthy functioning of the brain is characterised by the formation of transient functional alliances between different brain regions mediated by synchronous oscillatory activity. Recent developments in signal analysis have begun to make it possible to test these ideas in humans using electroencephalogram (EEG) measures of functional connectivity. The aim of this study was to apply some of these recently developed methods to help identify abnormalities of functional co-ordination in the brains of patients with schizophrenia. EEG recordings from 35 un-medicated patients with schizophrenia (15 positive and 20 negative syndrome) were compared with 24 healthy controls during Eyes Open and Eyes Closed resting Conditions. The patient groups not only showed lower overall levels of connectivity across all frequency bands than the controls but also showed a different pattern of

connectivity. In particular, patients showed a less clustered pattern of connectivity and lower inter hemispheric communication. The implications of these findings and the strengths and limitations of the methodological methods used will be discussed.

THE ANALYSIS OF NEUROFEEDBACK DATA: A SUITABLE THEORETICAL AND STATISTICAL FRAMEWORK

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Background

The design and analysis of neurofeedback experiments poses several problems related to (among others) the definition of the learning process, the treatment of extra-cranial artifacts, and the group averaging of individual learning curves.

Methods

A suitable theoretical and statistical framework will be delineated. First, the kinds of learning process that can be shown as a consequence of the neurofeedback treatment will be defined. Second, appropriate experimental designs to uncover them will be explained. Third, the use of single-subject permutation-randomization analysis of covariance (ANCOVA) will be shown to handle artifacts (treated as covariates), while quantifying the experimental evidence for all kinds of learning process as previously defined. Finally, the parametric combination of p-values will be proposed as a flexible method to derive group-based statistical inference.

Results

The proposed framework is shown to be valid in a wide range of experimental designs where learning curves are of concern, and also powerful, specific, rapid, and flexible. The statistical method is the same for all learning processes and is easily understood by non-specialized audience. All necessary computations can be performed with freeware software. All www resources will be provided.

Conclusions

After over 30 years of research in neurofeedback, there are not reference methods for the analysis of neurofeedback data. There is no consensus even on what a neurofeedback learning process is or should be. The aim of this work is to propose a framework capable to categorize previous research according to the kind of learning process investigated and to offer a suitable method for the treatment of experimental/clinical data.

ELECTROMAGNETIC TOMOGRAPHIC NEUROFEEDBACK II: THE WHOLE STUDY

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Background

Last year in Udine we presented a pilot study (n=3) on LORETA Neurofeedback. In the meanwhile we

completed the study adding three subjects. With this presentation we aim to report new results and to discuss future research directions. The Neurofeedback based on Low-Resolution Electromagnetic Tomography (LORETA) has been conceived to overcome some limitations of the current neurofeedback paradigm, namely, the limited information provided by a single or a small number of electrodes placed on the scalp, and the choice of the reference electrode. By means of inverse solutions techniques such as (LORETA) spatially delimited brain activity can be evaluated in intracortical tissue. The task is to feed back in real-time LORETA current density.

Methods

Six individuals were trained to improve brain activation (suppress low Alpha (8-10 Hz) and enhance low Beta (16-20 Hz) current density) in the anterior cingulate gyrus cognitive division (ACcd). Three participants took part of six experimental sessions, and three of 20 experimental sessions, each lasting approximately 30 minutes. Permutation-randomization analysis of covariance was performed on learning curves of the target activity during the sessions and on a set of randomized trial subministered at the end of the treatment. Randomized trials consisted of eight two-minutes periods (trials) for which participants were asked to try to obtain as many rewards as they could (4 "plus" trials) or as few rewards as they could (4 "minus" trials). The order of trials was decided at random. We tested the hypothesis that the Beta/Alpha ratio increased over sessions (learning curves) and that participants acquired volitional control over their brain activity so to be able to obtain more rewards during the plus condition as compared to the minus condition (randomized trials).

Results

We performed single-subject analysis and we obtained group (n=6) inference by means of parametric p-value combination (additive and multiplicative methods). For the randomized trials we found strong evidence of volitional control of the Beta/Alpha ratio (additive: $p=0.012$; multiplicative: $p=0.002$). For the learning curves we found weaker, yet substantial, evidence of increased Beta/Alpha ratio over session (additive: $p=0.152$; multiplicative: $p=0.007$). Single-band analysis revealed that both effects were driven by the Beta band.

Conclusions

The experiment showed overall signs of volitional control and increased Beta/Alpha electrical activity in the target region (ACcd). Tomographic neurofeedback has never been done before and is very promising. Possible applications of the technique include the treatment of epileptic foci, the treatment of specific brain regions damaged as a consequence of traumatic brain injury, and in general of any specific cortical electrical activity. We are now designing a sort of 3-D brain voyager, an advanced interactive graphic representation of the brain to offer more direct and reliable neurofeedback.

PEAK ACHIEVEMENT TRAINING OF THE TOP EXECUTIVES OF A FORTUNE 1000 COMPANY: IMPROVEMENTS IN AN EEG MEASURE OF CONCENTRATION

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Background

A Fortune 1000 company has created a Peak Performance Center as part of their leadership development

program. It was patterned after the program at the Center for Enhanced Performance at the United States Military Academy at West Point, the U.S.'s largest performance enhancement center, which was started by one of the authors (LC) in 1989.

Methods

The top 22 executives at Hillenbrand, Inc. participated in a 20 session program, which included training on the FreezeFramer; respiration, EMG, and skin conductance preceding EEG training to enhance concentration performed on the Peak Achievement Trainer. The executives participated in five hour-long sessions of Peak Achievement Training, consisting of individual coaching based on (with elaboration) the Peak Achievement Trainer's workbook, including about 35 minutes of practice on the InAll wideband suppression protocol per session. In the first and the last session, they were tested by measuring how long they could hold their InAll levels below 30 microvolts.

Results

During the pre-test, the first trial averaged 19 seconds, ranging from 10 to 40. The first trial in the post test was more than twice as long, 44 seconds, with the range running from 25 to 65 seconds. The average duration of the best trial per session almost doubled from 65 seconds at the pre-test to 128 seconds at post test. The ranges were 18 to 180 and 48 to 220, respectively. This is clear evidence of very rapid learning.

Conclusions

This is clear evidence of very rapid learning. Response to the program was overwhelmingly positive, with notable improvements in their ability to attend in crucial meetings, engage in critical performance appraisals with employees, and deliver exceptional presentations. These executives have returned voluntarily for many additional sessions, primarily using the Peak Achievement Trainer's ConAlert protocol, and the program is being expanded to 39 more executives. They are writing an article for Harvard Business Review.

ABNORMAL NEURAL COMMUNICATION AND NETWORKS IN PSYCHIATRIC DISORDERS

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A psychiatric disorder can be viewed as a manifestation of a maladaptive brain organisation that arises from unfavourable interaction of genome and environment. At its core resides an abnormal cerebral network architecture with altered neural connectivity and communication. These changes lead to neuropsychological, cognitive and behavioural malfunctioning that give rise to the psychiatric symptoms on the subjective and behavioural level. Consequently, the diagnosis that relies exclusively on this most superficial level (e.g., ICD/DSM-classifications) is hampered by the sources of variability that occur between the different levels of manifestations (outlined in Fig.1 for psychotic illness).

There is, however, no need to rely exclusively on "surface" measures for classification of disease and diagnosis. It has become possible to directly map dysfunctional neural networks in the brain by recording abnormal magnetic brain activity. Focal electromagnetic slow waves, for instance, are generated in the surround of circumscribed pathological or lesioned brain areas. Abnormal focal spontaneous brain activity may occur as slow wave lesional activity, as epileptic spikes, and as seizure activity. Typical lesions producing a variety of abnormal waves include cerebral infarcts, contusions, local infections, tumors, developmental defects, degenerative defects or subdural hematomas. Abnormal slow waves not only result

from neurological disease, but are also commonly observed in a variety of psychopathological conditions. We examined to what extent local clustering of magnetic slow wave generators was related to symptomatology and neuropsychological functioning in patients with DSM-IV diagnoses and to what extent such clusters mark dysfunctional brain areas.

Spontaneous magnetic brain activity was recorded with a whole-head neuromagnetometer in 82 schizophrenics, 80 patients with PTSD, 14 with affective disorders, 12 alcohol dependent, and 35 healthy subjects during 5-min periods of rest. For bandpass-filtered data in the delta (1.5 – 4Hz) and theta (4Hz – 8Hz) ranges, the origin of focal slow waves was determined (using a single equivalent current dipole model) and the number of generators was counted per voxel, i.e., a density function of focal generators was computed.

In most patients these density functions were circumscribed, limited to one or a few focal brain regions generating large amplitude slow waves. The localization of these foci was group-specific for both the delta and the theta bands. Consistently more slow waves were observed in left temporal and parietal regions in schizophrenic patients (Figure 2), and were correlated with more symptoms (temporal abnormality with hallucinations) and more perseverative errors in neuropsychological tests. We did not find differences in the focal clustering of delta and theta slow waves between schizophrenic patients with and without neuroleptic medication. A weak negative correlation observed between temporal theta activity and neuroleptic dosage might be mediated by severity of symptoms.

Depressive patients exhibited a suppression of frontal activity compared to any of the comparison groups. Less attenuation was apparent when patients had responded favourably to medication. In PTSD patients we generally observe left frontal islands of focal slow waves. The group-specific pattern of slow wave activity was not affected by mental activation.

The enhanced slow wave activity in the majority of psychotic patients points to a dysfunction and decoupling of left-hemispheric perisylvian language regions from other brain areas.

In conclusion, the mapping of abnormal slow waves (ASWAM) is a potential diagnostic and prognostic tool for psychiatry as well as neurology. We conclude that focal slow wave activity, localized by means of magnetic source imaging is indicative of dysfunctional brain regions in psychiatric disorders and should be evaluated as a diagnostic and prognostic measure. Moreover, the mapping of dysfunctional neural networks may also help us to understand these disorders from a neuroscience perspective.

SCALP AND INTRACEREBRAL (LORETA) THETA AND GAMMA EEG COHERENCE IN MEDITATION

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Background

Changes in EEG coherence, and in theta and gamma EEG frequencies were reported in meditation. Since, however, scalp locations do not necessarily indicate directly underlying sources, only coherences computed between intracerebral model sources can reveal interpretable, functional connectivities between brain areas.

Methods

27-channel EEG was recorded from a long-term meditator while repeatedly performing three different

meditations (Ch'an Buddhism), and during a control condition, in 4 identical, independent sessions. From the first 3 minutes during meditation and control, all artifact-free 2-second EEG epochs (N=2323) were analyzed. Intracerebral model sources were computed using LORETA for 2394 voxels; each voxel was assigned to the closest scalp electrode position, forming 27 cone-shaped brain regions of interest (ROIs). Theta (6.5-8 Hz) and gamma (35-44 Hz) coherences were computed between all pairs of scalp EEG electrodes and between all pairs of intracerebral LORETA ROIs. T statistics compared the coherences between control versus meditation.

Results

During meditations compared to control, all significant changes in theta coherences were increases, while most in gamma were decreases, both for scalp EEG and for LORETA. But, the spatial distribution of scalp and LORETA coherences differed strongly (both for theta and for gamma). E.g., the ratio of significant coherence changes involving anterior compared to posterior locations was 95 to 30 for scalp EEG, but 12 to 17 for intracerebral LORETA ($\chi^2 = 13.3$, $p=0.003$). Theta LORETA coherences increased in all three meditations. Gamma LORETA coherences predominantly showed decreases, but, consistent in the three meditations, had isolated increases in both temporal brain regions (anterior-posterior).

Conclusions

As expected, scalp computed EEG coherences differed from intracerebrally (LORETA) computed coherences. During meditation, the relevant LORETA results showed general coherence increases for theta, and decreases for gamma, but gamma also showed isolated increase in both temporal regions.

EMOTIONAL PROCESSING IN SUBJECTS WITH PANIC DISORDER

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Background

Subjects with Panic Disorder (PD) have high scores on alexithymia, a tendency to interpret ambiguous stimuli as threatening and an attentional bias toward threat-related cues. Several findings suggest that a dysfunction of temporo-limbic regions, in particular those of the right hemisphere, involved in emotional processing, might underlie these characteristics.

Methods

Alexithymia was evaluated by the Toronto Alexithymia Scale in 17 drug-free patients with DSM-IV PD and matched healthy controls (HC). In all subjects ERPs were recorded from 30 channels during a visual target detection task, in which stimuli with different emotional valence (neutral, erotic, threat-related and phobic) were used as distractors. The Low resolution Electromagnetic Tomography (LORETA) was used to identify cortical generators of the ERP P3a component for distractors.

Results

Alexithymia was more frequent in PD subjects than in HC. Comparison between erotic and neutral distractors revealed a different pattern of activation in HC and PD subjects: an activation of the anterior cingulate, insula and medial frontal areas was observed in HC, while a reduced activation of the right parieto-temporal regions was found in PD subjects. In HC no difference in activation patterns was found

when comparing threat-related and neutral stimuli, while in PD subjects a reduced activation of right temporal regions was observed when the same comparison was performed.

Conclusions

The results confirm the presence of a reduced activation of right hemisphere integrative areas during emotional stimuli processing in subjects with PD.

THETA STATES THROUGH NEUROFEEDBACK, HYPNOSIS AND ENERGY MEDICINE

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First the efficacy of the enhancement of alpha theta in elevating artistry to a professionally significant degree in conservatory students will be outlined, as it represents the first attempt to validate the protocol as a sole intervention. The implications will then be discussed of ancillary experiments designed to explore relaxation as a mediator, temporal changes in theta-alpha ratio within and between sessions, and post-training alterations of the topographical EEG. The relative influences of faster wave training on performance will also be outlined. A phenomenological analysis of the musician's experience will be reviewed, and together the results will be considered in the light of the historical development of alpha theta training and earlier applications aimed at treating anxiety and addiction. The limitations of our current state of knowledge about the applicability of this paradigm will be considered and open discussion will be encouraged. Current knowledge about the role of theta in psychological processing will be covered. Can other interventions such as autonomic biofeedback, meditation, hypnosis and energy medicine achieve similar goals? Comparative studies are underway. References will be provided.

INCREASING COGNITIVE PERFORMANCE IN HEALTHY SUBJECTS BY NEUROFEEDBACK

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Background

From several EEG studies (Klimesch, Doppelmayr, Pachinger, & Ripper, 1997; Doppelmayr, Klimesch, Stadler, Pollhuber & Heine, 2002), there is good evidence that high power in the upper alpha band and low power in the theta band preceding a task is related to good cognitive performance. This study investigated the hypothesis whether an increased absolute alpha power or a decreased absolute theta power is capable of increasing cognitive performance.

Methods

Twenty-one healthy subjects were instructed to increase their absolute upper alpha power, or decrease absolute theta power with neurofeedback training. Mental rotation tasks were presented before and after neurofeedback training.

Results

After upper alpha training the subjects performed better on mental rotation tasks but not after theta

training. Additionally it could be demonstrated that the pre-stimulus power in the upper alpha band increases after training.

Conclusions

This is well in line with other studies (Klimesch, Gerloff, & Sauseng, 2003) which showed that high upper alpha power in the pre stimulus interval is related to good cognitive performance. This study shows that neurofeedback training can be used to increase cognitive performance by way of those factors which are known to underlie good cognitive performance under normal conditions.

ENHANCED EEG ALPHA PHASE SYNCHRONY IN PRACTITIONERS OF THE TRANSCENDENTAL MEDITATION TECHNIQUE

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Background

Analysis of phase synchrony over large cortical distances has become increasingly important in the study of normal and abnormal brain function. Deficiencies in long-range phase synchronization described by Bhattacharya (2001) have been tied to brain pathology. Recent research suggests that phase locking and phase coupling mechanisms may transfer information or functionally integrate large-scale neurocognitive networks. The present investigation examines the effects of long-term transcendental meditation (TM) practice on EEG phase synchrony.

Methods

Nineteen channel EEG of 15 long-term practitioners of the TM technique is recorded during eyes closed resting conditions. Fifteen volunteers matched for gender, age and education served as Controls. Quantitative EEG analysis in standard delta, theta, alpha and beta bands is performed using Neurorep (NREP4) PHASE program.

Analysis of forty seconds of data for each subject yielded an average millisecond time delays (phase-lag) for each electrode pair at each frequency.

Results

The fifteen TM subjects show more alpha (7-13 Hz) long-range (front-to-back) phase synchrony, as compared to the Control group. Though both groups showed more alpha phase synchrony than the younger normative database, the TM group had twice the number (177 vs. 87) of significantly shorter phase delays than the Controls ($P < .05$).

Conclusions

The results support a field theory of consciousness (John, 2001) where neuronal populations become more integrated at lower levels of excitation. Increased alpha phase synchrony found here suggests that long-term TM practice enhances the functional integration of large-scale neuro-cognitive networks.

References

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THE THOUGHT-TRANSLATION-DEVICE (TTD): EXTENSION TO AN AUDITORY BRAIN-COMPUTER COMMUNICATION SYSTEM

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The Thought Translation Device (TTD) is a brain-computer-interface based on the self-regulation of slow cortical potentials (SCPs) and enables severely paralyzed patients to communicate using their brain potentials. However, many locked-in patients are no longer able to focus their gaze on a computer's screen. Therefore an extended version of the TTD provides all feedback information necessary for brain-computer communication over the auditory channel. To evaluate the system a first study with 3*18 healthy participants was carried out to test the performance of physiological regulation under three different feedback conditions: Visual, auditory, or combined visual-auditory feedback of slow cortical potentials. The training consisted of three sessions with 1500 trials with a random assignment of required cortical positivity or negativity. The results show that physiological regulation of SCPs can be learned with auditory and combined auditory and visual feedback although the performance is significantly worse than with visual feedback alone. In a next step two auditory communication paradigms are presented: An auditory letter selection program that tells a patient the letter sets with a computer's voice as well as the resulting response. For less skilled patients a question answering system was developed presenting questions and allowing them to answer them with brain responses. An example with a completely paralyzed patient shows that even with unreliable brain control significant answers can be obtained. The results of a first application to a completely paralyzed patient are presented.

UNLOCKING THE LOCKED-IN: BRAIN-COMPUTER COMMUNICATION IN PARALYSED PATIENTS

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Neurological disorders like cortico-subcortical stroke or degenerative neuromuscular diseases can lead to "locked-in" syndrome, a state of complete motor paralysis with intact sensory and cognitive functions. One of the most terrifying aspects of this syndrome is the loss of the ability to communicate. To re-establish communication in severely paralyzed patients, we have developed an EEG-based brain-computer interface. Visual feedback of electrocortical activity and operant conditioning have been combined to train patients to operate this communication device by generating shifts in their slow cortical potentials. When a patient has achieved reliable control over his/her slow cortical potential shifts, these responses can be used to select or reject items (letters, commands, links in an internet browser) presented on a computer screen. This talk will highlight recent progress in brain-computer communication in the severely paralyzed. This includes research on the cortical mechanisms underlying the voluntary production of slow cortical potential shifts. Functional magnetic resonance imaging in both healthy volunteers and patients with neurodegenerative diseases has shown that during the preparation interval preceding a required slow cortical potential shift, there were increased activations in widespread central and precentral regions. During the active phase, this was followed by distinct activation differences in the vicinity of the feedback electrode. Finally, future

developments will be outlined including feedback and self-regulation of regional brain activity using real-time functional magnetic resonance imaging.

THE FUNCTIONAL MEANING OF ONGOING AND EVOKED OSCILLATIONS FOR MEMORY

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Background

The question is addressed whether event-related potentials (ERPs) are generated by a superposition of evoked oscillations in the theta and alpha frequency range. We develop this hypothesis within the framework of an oscillatory phase resetting model for ERP generation. Furthermore, we investigate the question whether evoked theta and alpha have a similar functional meaning for memory as is known from event-related de/synchronization (ERD/ERS).

Methods

For a series of memory experiments we compare 6 different electrophysiological measures, ERD/ERS, ERP, phase locking, evoked power, phase synchronization and m:n phase synchronization.

Results

Our findings indicate that (i) theta and alpha show a significant increase in phase locking during the time window of early ERP components as compared to a prestimulus reference, (ii) the dynamics of event-related changes in evoked theta and alpha power obey the same principles as are known from event-related de-/synchronization research and (iii) latency measures of the P1-N1 complex are negatively correlated with individual alpha frequency. In addition, we have found that theta phase locking is larger during encoding than recognition and that good memory performers show a larger increase in theta and alpha phase locking during recognition in the time window of the N1.

Conclusions

The reported findings suggest that cognitive performance may be based at least in part by an interplay between the synchronous activation of three neuronal network systems, a working memory, attentional, and semantic memory system, each operating with a different frequency, the first in the theta (about 6 Hz), the second in the lower alpha (about 8 Hz) and the third in the upper alpha (about 12 Hz) frequency range. The implications of this theoretical framework are discussed by considering phase sensitive measures to analyze 'local' and 'large scale' integration processes between different neural networks.

EEG AND ERP MICROSTATES, THE ATOMS OF THOUGHT AND EMOTION

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Studies of human brain electric fields indicate that the "stream of consciousness" actually consists of identifiable, brief building blocks. This is based the observation that momentary landscapes of the spatial distribution of brain electric potential change in a discontinuous manner. Short periods of quasi-stable potential landscapes (~100 ms, called 'microstates') are concatenated by rapid transitions. Since different

distributions of potential must have been produced by different neural populations, microstates can reasonably be assumed to incorporate different brain functions. In schizophrenic patients before medication, microstates of two classes (defined by potential landscapes) were shorter in duration than those of controls, suggesting precocious termination of certain classes of information processing in the patients. Moreover, sequencing of the microstates was different in the patients, suggesting deviations in "mental grammar" in schizophrenic disorder. The hypothesis that different microstates incorporate different brain functions was supported by microstate studies during spontaneous thoughts (prompted reports during the "stream of consciousness") and during reading of single nouns: microstates preceding reports of spontaneous, visual imagery differed from microstates preceding reports of spontaneous, abstract thought in the same way as microstates after reading an imagery-inducing noun differed from microstates after reading an abstract thought-inducing noun. In both experiments, LORETA functional tomography showed stronger right posterior activity for visual imagery, and stronger left anterior activity for abstract thought, regardless whether spontaneously occurring or reading-induced. These results suggest that it is promising to work towards a dictionary of the psychophysiological "atoms of thought", the building blocks of mentation.

CONSTRAINT-INDUCED MOVEMENT THERAPY (TAUB'S TRAINING) FOR STROKE PATIENTS WITH CHRONIC MOVEMENT DISORDERS: BEHAVIORAL EFFECTS AND CORTICAL REORGANIZATION

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The relative dearth of effective interventions for motor disorders in stroke patients and those with traumatic brain disease represents one of the most challenging problems of rehabilitation medicine and rehabilitation psychology. Although a broad variety of methods has been applied in different fields of rehabilitation only a few of them were rigorously tested by controlled studies and confirmed to represent successful treatment approaches whose therapeutic short-term effects positively transfer from the treatment environment into the real world of patients. A family of treatment methods, called Constraint-Induced Movement Therapy (CI-Therapy), first suggested by Taub, represents one recent exception of this dissatisfactory condition. In a recent outcome study we tested this approach empirically in more than 70 patients with persistent movement disorders of the upper extremity following stroke and in 8 stroke children.

One basic idea of this approach hypothesizes that a large portion of movement disorders following stroke are not primarily related to the neurological damage induced by the stroke itself but to a conditioned suppression of movements initiated by a diaschisis-related failure of limb functioning and by extensive compensatory use of the less-affected limb during the post-stroke period. As shown by our study and similar studies by others many stroke patients are able to reach good movement functions with their stroke affected upper limb when systematically trained to overcome this learned suppression of motor function by intensive behavioral training of the affected limb for a period of 12 consecutive days and many hours of training per day. The talk will briefly summarize some of the initial animal and human experimental studies from which this approach was generated and then present some of its basic treatment principles. Furthermore, evidence from experimental studies on brain electrical activities and imaging of brain activities during voluntary and passive movements in stroke patients pre and post treatment will be presented indicating that positive treatment effects of CI-Therapy are associated with massive cortical plasticity and

reorganization of cortex areas involved in motor control. It is hypothesized that the long lasting behavioral effects of CI-Therapy are based on treatment-induced cortical reorganization of such motor output areas.

CLINICAL PERTINENCE OF DRUG INDUCED AUTONOMIC DYSFUNCTION WHILE APPLYING BIOFEEDBACK IN PATIENTS

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Background

Most antidepressant drugs lead to enhanced synaptic availability of the neurotransmitters serotonin and/or norepinephrine. However, affecting also other transmitters, e.g. acetylcholine, antidepressants cause peripheral autonomic dysfunction (e.g. dry mouth, tachycardia). Aim of our study was to objectify these autonomic dysfunction with respect to its consequences for biofeedback applications in psychosomatic and psychiatric patients.

Methods

Therefore, we applied simultaneous recordings of ECG for assessment of heart rate variability (HRV), as well as skin blood flow and skin conductance level - indicating peripheral autonomic responses like inspiratory gasp response (IGR) and skin conductance response (SCR) - to patients under treatment with psychotropic drugs (amitriptyline, olanzapine, clozapine, fluoxetine, or hypericum extract; n=20 each).

Results

We found that heart rate variability was reduced in all patients treated with amitriptyline, olanzapine, or clozapine but not under treatment with fluoxetine, or hypericum. Exclusively in amitriptyline-, olanzapine-, clozapine-treated patients 1) redilation of IGR was prolonged, indicating inhibition of norepinephrine re-uptake, and 2) in about 50% of these patients SCR was blocked completely, or reduced in the other 50% (due to anticholinergic effects).

Conclusions

We suggest that these autonomic dysfunction are due to various interactions of these drugs with neuronal structures and pathways (e.g. alpha 1-, alpha 2-, M2-, M3-receptors, inhibition of norepinephrine re-uptake).

Applying biofeedback on psychiatric or psychosomatic patients, one should keep in mind that some psychotropic drugs interact with autonomic functions.

AUTOMATICITY OF THE SKILL TO SELF- REGULATE SLOW CORTICAL POTENTIALS

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Direct brain-computer communication utilizes self-regulation of brain potentials to select letters, words or symbols from a computer menu. Selection of letters or words with brain potentials requires simultaneous processing of several tasks such as production of certain brain potentials at predefined time points simultaneously with processing of presented letter strings. This study addresses the question if the self-

regulation of slow cortical potentials (SCP) automatizes with practice and can thus be considered as a skill comparable to motor or cognitive skills. Two nearly completely paralysed patients learned over several months to produce electrocortically negative and positive SCP by means of visual feedback. Improved performance and a reduction in performance variability were regarded as behavioural indicators for automaticity, while the topographic focalisation of cortical activation was considered as a neurophysiological indicator for automaticity. Different indicators of automaticity were expected to covary along with practice. In patient 1, performance measured as the percentage of correct SCP shifts increased simultaneously with the topographic focalisation of cortical activation. His performance became more stable with practice. For this patient the criteria for automaticity were all met. In patient 2, performance also improved, but his cortical activity became topographically less focal. His performance was less stable than patient 1's.

NEUROFEEDBACK AS A COMPLEMENTARY THERAPY IN ADDICTIONS TREATMENT

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Background

Neurofeedback was systematically evaluated as an adjunctive treatment for drug and alcohol addiction at a residential center in a large-scale study of 121 subjects. Participants had principally abused methamphetamine, heroin, cocaine (including crack), and alcohol, either alone or in combination.

Methods

Two treatments were compared: 1) the control, which consisted of the standard treatment provided at the residential center, based on the Minnesota Model incorporating sustained involvement in group work to support abstinence; 2) the experimental, which consisted of the control treatment plus neurofeedback. To minimize the possibility that treatment outcome differences were attributable to total time spent in therapy, the control participants were provided extra group and individual psychotherapy sessions, so that their hours of participation in treatment matched that of the experimental participants. Neurofeedback protocols included SMR-beta and alpha-theta training. The neurofeedback was individualized to the participant based on assessment data and response to the training protocols. Cognitive data were acquired pre- and post-treatment. Pre-post MMPIs were also obtained.

Results

Results showed that the experimental group had significantly increased retention in therapy compared with controls. Continuous performance test data showed significant improvement in the experimental group, but no significant change in the control group. Analysis of other cognitive data revealed a significant treatment interaction only for delayed memory performance. Changes in the MMPI were significant at the $p=0.005$ level for five of ten subscales: Hypochondriasis, Depression, Conversion Hysteria, Schizophrenia, and Social Introversion; there was a significant treatment interaction. Two additional scales, Psychopathic Deviate and Psychasthenia, showed significant change but no treatment interaction. Finally, one and three year follow-up data show a significant treatment interaction: experimentals were more than twice as likely as controls to sustain abstinence, irrespective of drug of choice.

Conclusions

These outcomes suggest that neurofeedback could play an important role in treatment of addictions.

THE COMBINED USE OF HAEMOENCEPHALOGRAPHY AND NEUROFEEDBACK IN STROKE REHABILITATION: A SINGLE CASE STUDY.

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Background

This poster presentation describes the therapy of a 64 years old male who during the previous seven years had suffered two heart attacks and three cerebro-vascular accidents (strokes), leaving him with considerable functional impairment. In particular he had no expressive language skills, did not orient to anybody except his wife, had violent outbursts and was doubly incontinent. He was referred initially for neurofeedback to help with his double incontinence.

Methods

A combination of Haemoencephalography (HEG) and Neurofeedback was used. HEG was used initially to help with perfusion levels in the frontal cortex. Once these had stabilized, Neurofeedback was used to help with the incontinence. The presentation will describe in detail the rationale for this approach.

Results

HEG was carried out for twelve sessions. The mean perfusion levels rose from a score of 23.4 at assessment to a score of 83. after 10 sessions. This maintained for two further sessions. The use of HEG was successful in improving expressive language function and in contributing to a reduction in aggressive behaviour.

The Neurofeedback protocol involved inhibiting hi-beta and theta wave activity posteriorly while recruiting low beta activity.

Conclusions

The use of HEG and Neurofeedback led to functional improvement in a markedly impaired individual. However, the progress of the sessions highlighted the need for careful consideration of the use of Neurofeedback in such an impaired individual.

CENTRAL NERVOUS SYSTEM DYSFUNCTION IN CHRONIC FATIGUE AND IMPLICATIONS FOR THERAPY

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Background

Chronic Fatigue is a central feature of CFIDS (USA)/ME (UK). Neurofeedback protocols, which involves inhibiting slow wave activity (2-8Hz) whilst recruiting faster wave activity (12-16Hz) in the frontal cortex, have been reported to be of help for this client group.

Methods

In our practice we have found three sub-types of C.N.S. dysfunction each of which requires different Neurofeedback protocols:

1. Group 1: Frontal-central
2. Group 2: Right-frontal
3. Group 3: Temporal lobes

Each of these sub-groups requires a different emphasis in its medical management.

Results and Conclusions

This presentation will outline the characteristics of each client group and the rationale for Neurofeedback approaches. The implications for medical management and a refining of the diagnostic categories will also be discussed.

HAEMOENCEPHALOGRAPHY AND NEUROFEEDBACK WITH INCONTINENCE

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Background

Urinary incontinence is the inability to control urination. A frequently used term is Over Active Bladder (OAB). The disorder affects up to 1/2 - 1% of the adult population but only about 10% of people seek treatment. Treatments conventionally used include medicine, surgery, behavioural therapy, absorbent products and devices. Some of these treatments help manage the problem. This paper describes two single case studies: The first that of a 19 year old female university undergraduate. The second, that of a 64 year old male who had suffered two heart attacks and three cerebro-vascular accidents (strokes) leaving him with considerable functional impairment. He had no expressive language skills, did not orient to anybody except his wife, had violent outbursts and was doubly incontinent.

Methods

Both subjects received weekly Neurofeedback Sessions. For the young lady, the protocol was guided by her QEEG and involved posterior alpha-wave training. The protocol for the male, involved a combination of Haemoencephalography (HEG) and Neurofeedback. HEG was used initially to help with perfusion levels in the frontal cortex. Once these had stabilised, Neurofeedback was used to help with the incontinence. The Neurofeedback protocol involved inhibiting hi-beta and theta-wave activity posteriorly, whilst recruiting lo-beta wave activity.

Results

Subject 1: Prior to Neurofeedback, subject reported day-time incontinence occurring 2 – 3 times per week and bedwetting nightly.

Following three Neurofeedback sessions, the young lady reported no incidences of daytime incontinence. The total cessation of bedwetting took longer. Subject 2: HEG was carried out for twelve sessions. The mean perfusion levels rose from a score of 23.4 at assessment to a score of 83.2 after 10 sessions. This maintained for two further sessions. The use of HEG was successful improving expressive language function and in contributing to a reduction in aggressive behaviour. Faecal incontinence eased after 6 Sessions of Neurofeedback and urinary incontinence lessened.

Conclusions

These two single case studies demonstrate the effectiveness of Neurofeedback with incontinence. The

second case highlights the need for the careful consideration of the use of Neurofeedback in such an impaired individual.

FUNCTIONAL “WIRING” OF THE BRAIN BASED ON VIRTUALLY IMPLANTED ELECTRODES

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Background

A large number of ERP connectivity and synchronization studies utilize measures of coherence and phase locking computed from pairs of multichannel scalp electric potential differences. ERP signals contain information on brain activity. However, a well-known fact about the EEG/ERP inverse problem insures that the electric potential difference at a certain scalp location does not necessarily reflect the activity of the underlying cortex. In this study, electric neuronal activity is estimated with standardized low resolution brain electromagnetic tomography (sLORETA) (Pascual-Marqui, Method Find Exp Clin 2002, 24D:5-12). These signals are then used as a basis for assessing, directly, functional intracortical connectivity.

Methods

Three-dimensional (3D) spatio-temporal signals of electric neuronal activity are estimated with sLORETA. This method is uniquely capable of exact (zero error) localization. In addition, it has the lowest spatial dispersion as compared to other published 3D linear, discrete, distributed EEG/MEG tomographies. sLORETA provides high time resolution signals of “virtually implanted electrodes” throughout the cortex. These 3D spatio-temporal signals are then analyzed in terms of independent components (Cardoso, Icassp'89:2109-2112), with independence being forced in the time domain, not in the spatial (cortical) domain.

Results

In an hemifield visual ERP experiment, time lagged interhemispheric connections between the visual cortices are demonstrated. These results are remarkably similar to those produced by microstate segmentation modeling.

Conclusions

It may seem paradoxical that “independent” component analysis (ICA) should yield information on “connectivity”, since these two concepts are quite at odds with each other. The fact is that this implementation of ICA, independence is forced on the time series of activations, while the spatial, 3D, dimension contains the information on intracortical connections. Experimental validation has been presented for method, which proves to be a powerful tool for modeling the functional “wiring” of the brain.

DYNAMICS OF BRAIN OSCILLATIONS

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One important feature of the brain is its ability to generate oscillations in alpha, beta and gamma bands. Different frequency components can display different reactivity patterns not only in the alpha, beta and

gamma bands, but also within these bands. So for example upper and lower alpha component reactivities can show an antagonistic behaviour.

There is strong evidence that gamma activity has to do with the "binding function" and alpha activity with the "gating function". It is speculated that the beta rebound within the first second after movement or somatosensory stimulation is linked with a "resetting function" of networks in sensorimotor cortex.

Electrocorticographic data from subdural electrodes in candidates for epilepsy surgery show that short-lasting gamma oscillations between 60 - 90 Hz are very frequent in a motor task and always embedded in desynchronized alpha activity. The gamma bursts are very focused, whereas the alpha desynchronization is relatively widespread.

QUANTITATIVE QUANTUM APPROACH TO NEURONAL ELECTRIC ACTIVITY

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Background

The discoveries in the field of neuroscience and biology in the last decade of the 20th century, in particular the superposition of different sensory images, the correlations of activities in different brain regions and the non-locality and persistence of memory, led to the idea that the high brain processes, such as memory and consciousness have a quantum origin. Consequently, many quantum models of memory have been proposed, some assigning special role of quantum rotators. However, the theoretical results obtained so far are of purely qualitative–conceptual nature, and therefore it is important to quantitatively analyze the quantum models.

Methods

Applying adiabatic quantum approach, we investigate the quantum aspect of neuronal processes in order to explore the hypothesis of the relation of memory with the interaction between quantum rotators and electromagnetic field. In particular, the possibility that memory is connected to the collective rotational energy levels of molecules is considered, analyzing the system consisting of molecular quantum rotators interacting with the cortical field.

Results

The resulting probabilities of quantum transitions appeared to be dependent on frequency only, and not on the field's strength, for the actual range of magnitude of the electric field in brain cells. The relevant number of water molecules, related to probability of transitions that corresponds to maximum information entropy for the frequency of electric field the cytoplasm is exposed to, is shown to be close to the number of water molecules per cortical neuron, estimated from the cortex anatomy data.

Conclusions

The obtained dependence of quantum transitions suggests that the field frequency could be the information-bearing physical quantity; this may justify its adjustment as the basic mechanism of neuronal regulation. The agreement between the numbers of water molecules obtained theoretically and empirically could confirm the correctness of the approach.

NEUROFEEDBACK AND PERIPHERAL BIOFEEDBACK STUDY OF CHILDREN EXPOSED TO LEAD EMISSIONS

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Background

The aim of the study is to investigate the psychophysiological functions in children exposed to lead emissions in the highly polluted city of Veles .

Methods

Measurements of blood lead levels, multimodal psychophysiological assessment with biofeedback equipment (EEG, EMG, BVP, SC, Temp. and Resp.), cognitive psychological tests (Raven) and investigation of graphomotor ability (Bender-Gestalt) on randomly selected children (n=31) from Veles have been performed.

Results

The obtained results have shown slightly increased blood lead levels in tested children (mean value 16,51 µg/dl), reflected correspondingly in the level of intelligence and graphomotor ability. In addition, the autonomous nervous system studied by peripheral biofeedback appeared to function normally, reacting adequately in stress situations. However, the EEG results have shown that only in two children the theta-beta ratio has normal values, while in others the obtained ratios correspond to increased attention deficit. Moreover, the two children with the highest theta-beta ratio showed pathological ADHD findings and also the highest blood lead levels (> 20 µg/dl).

Conclusions

The suspected correlation between increased blood lead levels due to industrial pollution and changes in EEG, toward increased attention deficit in tested children has been confirmed, implying the need for corresponding health care and environmental response measures. Compared to other applied psychometric instruments, neurofeedback appeared to be the most sensitive and discriminative modality.

THETA WAVES CAN BE SELECTIVELY ENHANCED

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Background

The central tenet of neurofeedback is that certain brain frequencies can be enhanced independently of others. There has been some doubt in the literature, however, as to whether or not theta waves are amenable to such alteration.

Methods

A case study is here reported of an individual undergoing alpha-theta training with eyes closed.

Results

The participant was able to elevate theta independently of other frequency bands with eyes closed, and this had a dramatic effect on his mood.

Conclusions

Theta waves can be selectively enhanced. Implications for research into the theta wave are discussed.

THE EFFECTS OF VISUAL STIMULATION ON THE EEG

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Background

Visual stimulation (VS) using goggles has been put forward as a complement to neurofeedback, and several studies have documented its effectiveness in treating pain, as well as in producing altered states of consciousness and improving academic performance. Its effects on the EEG, however, are not clear, and contradictory findings have been reported.

Methods

32-channel EEG was recorded during different VS conditions.

Results

Results will indicate whether apparent contradictions in the literature on VS and the EEG could be put down to direct stimulation of EEG equipment by VS goggles alone, or was due to individual differences in brain responsiveness to VS stimulation.

Conclusions

Conclusions will be drawn about the viability of future research into the effects of VS on the EEG.

THE ROLE OF EEG-THETA OSCILLATIONS FOR INTEGRATION OF CORTICAL STRUCTURES AND MEMORY SYSTEMS

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Background

Long-range connectivity between anterior and posterior cortical areas may play a very important role in memory processes. We also know that EEG-theta oscillations (around 5 Hz) are functionally related to working memory whereas alpha oscillations (around 10 Hz) seem to reflect long-term memory functions. In the present experiments the role of theta oscillations in integrating distributed neural circuits and different memory functions is investigated.

Methods

Two experiments were un. In the first abstract visual patterns and corresponding labels had to be encoded and later the correct label had to be retrieved when a pattern was shown. Stable latency shifts of evoked

theta activity between prefrontal and temporo-parietal electrode sites reflecting functional coupling of the underlying brain areas were investigated for memory encoding and retrieval. In the second experiment a task combining working memory and (semantic) long-term memory was run. The interplay between these two memory systems was studied by relating topographical dynamics of theta oscillations with EEG upper alpha power changes.

Results

In the first experiment stable latency shifts of evoked theta activity between bilateral prefrontal and right temporo-parietal electrode sites, with anterior sites leading the posterior ones, were found during memory encoding. Coupling between left prefrontal and bilateral temporo-parietal areas was obtained during retrieval. These hemispheric differences might reflect different processing demands. Whereas during encoding sequential processing of verbal and visuospatial information was required simultaneous access to this information was needed during retrieval. In the second experiment the following topographical dynamics were found for evoked theta oscillations: Theta waves were first spreading from anterior to posterior sites but then reversed their direction and spread from posterior to anterior. The time point of inversion of direction varied to a great extent between subjects but was related to the onset of upper alpha power decrease, reflecting activation of semantic long-term memory.

Conclusions

These results suggest that (i) storage functions of working memory depend on distributed prefrontal-temporal networks, (ii) theta oscillations seem to integrate neural circuits relevant for memory functions and (iii) that the interplay between EEG theta and alpha oscillations reflects integration of different memory systems.

DECOUPLING OF MIDFRONTAL DELTA-BETA OSCILLATIONS AFTER TESTOSTERONE ADMINISTRATION

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Background

Brain oscillations in specific frequency bandwidths have been argued to represent various aspects of information processing on distinct neuroanatomical levels. Whereas the lower frequency range (i.e., 1-8 Hz) is suggested to be implicated in the evolutionary older subcortical systems, higher frequencies (i.e., > 8 Hz) are argued to originate from thalamo-cortical and cortico-cortical interactions. In the present study the effects of testosterone on the coupling between the subcortical and cortical frequency bandwidths was investigated.

Methods

Sixteen healthy, right-handed volunteers were enrolled in a placebo controlled double-blind, within-subjects, cross-over design. On two testing days, which were separated by three weeks, between 9:00 and 10:00 a.m., participants received a single sublingually administration of 0.5 mg testosterone (with cyclodextrine as carrier) or placebo after which a baseline EEG recording was obtained (impedance: < 5 kOhm, sampling rate: 250 Hz, amplification: 20,000). Spectral power values (Hamming window) were averaged across all epochs within a single baseline and were then transformed to power density values for the delta (1-3 Hz), theta (4-7 Hz), alpha (8-13 Hz) and beta (13-30 Hz) frequency bands.

Results

Paired-samples t-tests revealed a significant increase in delta power after T administration over the midfrontal electrode site [$t(16) = 2.13$; $p = 0.05$]. Furthermore, whereas a significant Pearson's correlation was observed for delta and beta oscillations in the placebo condition [$r(16) = 0.773$; $p = 0.0001$], the latter coupling was completely abolished after testosterone administration [$r(16) = 0.230$; $p = 0.4$]. The difference between the two correlations was statistically significant [$Z(16) = 2.55$; $p = 0.01$].

Conclusions

The observed increases in subcortical generated delta power, which was automatically followed by cortical-subcortical decoupling, suggests the capability of testosterone to induce decreases in communication between the cortical-subcortical areas.

SEQUENCING OF EEG-RESPONSE COMPONENTS: IMPLICATIONS FOR LEARNING

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Meaningful neurofeedback must depend ultimately on the principles of procedural learning as applied to operant conditioning of the EEG. This, in turn, is a function of the sequence of EEG events and related neuronal alterations that accompany the training process. Recent advances in the understanding of procedural learning have disclosed the importance of several relatively independent phases, including acquisition, stabilization, and consolidation. Neurofeedback attempts the training of specific EEG events, a process which must appropriately address these phases. This review will focus on a potential EEG marker for learning potentiation and stabilization, and suggest a relationship with the important consolidation function of sleep.

TEMPORAL-SPATIAL CHARACTERISTICS OF EVENT-RELATED EEG RESPONSES AND COMODULATION PATTERNS IN SIGNAL PROCESSING AND STATE CHANGES

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Recent developments in quantitative EEG measurement have provided several new measures of brain function that are amenable to the analysis of both the timing and localization of cortical responses to functional perturbations. This information in turn provides insights into the sequencing and interactions involved in both normal and abnormal cognitive functioning. This presentation will focus on both "event-related EEG responses" in a signal processing task with normal subjects, and regional correlation changes in EEG frequency modulation ("comodulation") during specific state changes in clinical subjects. In the former, findings suggest that suppression of frontal cortex involvement follows initial signal detection and allows for efficient cognitive response. Sensory and motor EEG changes appear to be stimulus-bound, reflecting mainly sensory arousal and muscle activity. In the latter, functional changes associated with altered processing are

first reflected by dissociation in frontal areas, followed by reduced differentiation in temporal and parietal regions. These and other dynamics noted provide new clues for effective interventions with neurofeedback.

16 CASE STUDIES EXAMINING THE EFFICACY OF NEUROFEEDBACK IN MENTALLY RETARDED WITH THE APPROACH OF DELTA DOWN REWARD

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Background

According to the DSM-IV, Mental Retardation is significantly subaverage general intellectual functioning accompanied by significant limitations in adaptive functioning in at least two of the following skill areas: communication, self-care, home living, social/interpersonal skills, use of community resources, self-direction, functional academic skills, work, leisure, health and safety. Prior to this study we have seen very important and valuable effects of Neurofeedback in the study of children with Down Syndrome. This method is used by many clinicians to treat ADHD and GLDO cases so we wanted to examine the effects of NF in Mentally Retarded.

All 16 subjects had neurofeedback training. Almost all subjects had increased delta and theta over the cortex according to QEEG. Some of the subjects were not able to read and write; not talk more than two or three words, some had illegible handwriting, almost all had very poor attention, concentration memory, academic failures, impulsive behavior, very poor social skills. One subject had a severe balance problem, two of them had lack of inhibition in social and sexual behavior. The approach is to examine the improvements of these problems according to the training.

Methods

16 subjects ranging 6-24 years old attending private learning centers were previously diagnosed with mental retardation at various university hospitals. Sessions were completed between 40-120 depending on the case. Evaluation measures included QEEG analysis, questionnaire prepared by the center. NF trainings were performed by Lexicor Biolex software. NXLINK databank was used to determine if they have ADHD/ADD/GLDO with clinical judgement of the author. Lexicor QEEG signals were sampled at 128 Hz. Electrodes were placed according to QEEG analysis at P3-T5, P4-T6, C3-C4, T3-T4, F3-F4, F7-T5 with a 0-4 delta reward and inhibits at 4-8 Hz and T3-T5, T4-T6 with a 12-15 Hz SMR reward and inhibits at 4-8 Hz. F3-Fz, F4-Fz with 15-18 beta reward and inhibits at 4-8 Hz.

Results

15 out of 16 patients who received NF training showed significant improvement based on parent/teacher/questionnaire/QEEG reports. One showed no progress during or after the training.

Conclusions

Further study with controls and additional outcome measures is warranted.

EEG AND INTELLIGENCE: UNIVARIATE AND MULTIVARIATE COMPARISONS BETWEEN EEG COHERENCE, EEG PHASE DELAY AND POWER

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Background

The present study was conducted with the following objectives: (1) to evaluate the ability of the power spectrum of brain electrical activity to predict performance on neuropsychological tests and school achievement tests and (2) to develop a objective EEG Brain Performance variables to estimate the cognitive health of the brain.

Methods

Neuropsychological tests (WISC-R) and school achievement tests (WRAT) and 19 channels of eyes closed EEG were obtained from 477 individuals ranging in age from 6 to 18.79 years of age. The results of power spectral analyses of the EEG were correlated with the subtests of the WISC-R and the WRAT using the Pearson product correlation analysis. The top 50 variables with the highest correlations were selected for entry into a step-wise multivariate regression analysis for each sub-test of the WISC-R and WRAT and separate regression equations were obtained, including the 95% confidence intervals. The predictive multivariate regression equations were independently validated by comparing the predicted full scale IQ versus the measured full scale IQ in the original sample of 477 subjects. Another independent validation of the regression equations involved predicting full scale IQ from 280 traumatic brain injured patients whose neuropsychological tests and whose EEG samples were obtained using a different EEG acquisition system at different locations and a different times.

Results

The multivariate R with EEG as the independent variable and neuropsychological test performance as the dependent variable varied from 0.5 to 0.75 at $P < .00001$. The correlation between the predicted full scale IQ and the measured full scale IQ was 0.72. Independent validation of the regression equations using 280 TBI patients showed normal distributions of predicted IQ and correlations between predicted and observed that ranged from 0.58 to 0.82 ($P < .00001$).

Conclusions

Multivariate analyses of the EEG correlate with Neuropsychological test scores and school achievement with medium to high effect size. EEG coherence, EEG phase, ratios of power and power asymmetry were the strongest predictors of neuropsychological test performance and intelligence.

EEG BIOFEEDBACK AT PRESCHOOL ADHD: PREVENTION OF SCHOOL PROBLEMS

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Background

ADHD and dyslexia were found to have the genetic cause, with markers diagnosable already in infancy. Other factors of brain dysfunctions (perinatal asphyxia, fevers etc.) are mostly gained in the early age.

However, children with ADHD/LD enter the basic school without any specific treatment. Authors' thesis, coming from their clinical experience, projected the preschool neurofeedback treatment as the solution. The study of was sponsored by the Ministry of Education grant.

Methods

Children visiting "special" kindergartens because of their behavior were chosen for the study. The common cause of their problems was ADHD, frequently coincided with speech disorders, learning disabilities, enuresis, and accident proneness. Forty children, age four to seven years, completed the forty sessions training.

The following pre-post examinations were carried out:

1. EEG/ERP,
2. Wechsler, the battery of nineteen Neuropsychological tests,
3. The rating of children by caregivers in daycare centers.

Results

ERP response latencies significantly improved. IQ raised more than half of standard deviation; majority of children improved more than ten points in PIQ, one third in VIQ. The total number of thirty-five children improved their performance in the majority of neuropsychological tests. The children's communication skills improved either. The rating by caregiver improved as well. Half of the children was able to enter a regular basic school in the same year after the treatment, the second after one-year delay.

Conclusions

EEG biofeedback was proved as the method to prevent problems of ADHD/LD children in entering the school, the family problems caused by school problems, and the school system troubles. The results suggest neurofeedback could be recommended for the application in a preschool age. The results also open the question, why ADHD recovery is sought as late as after children enter the school, while it would be more reasonable to practice it as the prevention in the preschool age.

THE EFFECT OF DISTINCT NEUROFEEDBACK TRAINING PROTOCOLS ON WORKING MEMORY, MENTAL ROTATION AND ATTENTION PERFORMANCE

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Background

Previous research has shown that training to enhance one spectral component, i.e., low beta (12-15Hz), whilst simultaneously inhibiting another, i.e., theta (4-8Hz), was associated with improved performance on a semantic working memory task. However, it remains unclear whether such improved performance was the result of enhanced semantic processing, improved attentional processing or an improvement in generic working memory. Hence, the aim of this study was to extend and clarify the previous research by examining the effect of neurofeedback training to enhance low-beta and inhibiting theta on measures of attention and working memory.

Method

Twenty participants were randomly allocated to two groups, both of which attended ten sessions of neurofeedback training. Group 1 was given real feedback aimed at enhancing low-beta (12-15Hz) and inhibiting theta (4-8Hz), in contrast Group 2 received false feedback. To monitor participants awareness of group allocation performance questionnaires were administered at the end of each training session asking them to rate their ability to control their EEG. Pre and post neurofeedback training participants from both groups also completed the attention network task (ANT) and an n-back working memory task.

Results

There was no difference in mean performance ratings between the two groups regarding their perceived ability to control their EEG. Nevertheless, for those receiving real neurofeedback training there was no evidence of any change in either their low-beta or theta amplitudes or ratios ($p > .1$), this was despite a slight increase in points scored. From time1 to time2 both groups exhibited a reduction in commission and omission errors when completing the n-back task, and a decrease in response latencies when completing the ANT.

Conclusions

Participants who received real feedback and those that received false-feedback both reported similar levels of control with regard to changes in their EEG. Hence, such a paradigm represents a useful method for teasing apart the possible benefits of neurofeedback training relative to possible placebo effects. However, those receiving real feedback failed to exhibit any change in their EEG. This highlights the need for clarification of some of the procedural aspects of neurofeedback training, such as threshold setting, before we can fully assess the cognitive and behavioural effects of neurofeedback training.

RECENT ADVANCES IN SLEEP EEG RESEARCH: POSSIBLE IMPLICATIONS FOR NEUROFEEDBACK

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The neurophysiological mechanisms of sleep spindle generation have been well established by numerous studies and involve variations in membrane potentials in both thalamic and corticothalamic networks. Traditionally, predominance of sleep spindles over central or centro-parietal areas was taken for granted. The interest in spindles has been enhanced by recent findings in sleep EEG research. Factors affecting sleep spindles will be briefly explained. Of particular interest are the topographic studies of sleep spindle incidence or SMR/sigma power that seem to point to the existence of slow- and fast-spindle oscillations. Frontal spindles peaking at about 12 Hz have been found along with spindles of about 14 Hz more prominent over centro-parietal areas. These results have mainly been interpreted in relation to two functionally separated spindle generators. However, lower and higher frequencies of sleep spindles have also been attributed to a single mechanism: the duration of hyperpolarization-rebound sequence in thalamocortical neurons. Indeed, while long hyperpolarizations generate slower EEG frequencies, short hyperpolarizations cause faster EEG frequencies. Based on this and other considerations that will be pointed out, one could also assume that there is only one kind of sleep spindle, and that in some people there is also an anterior peak of alpha activity. Despite the growing body of knowledge, the definitive functional

meaning of sleep spindles still remains to be elucidated. The issues that prevent definitive conclusions will be reviewed. Furthermore, the thalamocortical system seems to be characterized by plastic mechanisms in which corticothalamic projections could play a fundamental role. Possible implications for EEG neurofeedback training will be addressed. It would also be of theoretical interest to investigate whether distinct neurofeedback training protocols (within and outside the sleep spindle frequency range) could induce different changes in spindle parameters, thereby shedding more light on the functional significance of sleep spindles.

COGNITIVE ACTIVATION, CEREBRAL BLOOD FLOW, MEASURED BY NEAR-INFRARED SPECTROSCOPY TO THE DEPRESSED PATIENTS (APPLICATION FOR DIAGNOSIS AND TREATMENT)

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Background

A variety of functional brain imaging methods are being used to identify cerebral areas with abnormal activity and to select targets for possible intervention. These technologies have good temporal resolution, are relatively noninvasive, such as fluoro-deoxyglucose positron emission tomography (FDG PET), functional magnetic resonance (fMRI), magnetoencephalography (MEG), and single photon emission tomography (SPECT). Near infrared spectroscopy (NIRS) is one of the recently developed methodologies for continuous monitoring of alterations in oxygenated (oxy-Hb) and deoxygenated (deoxy-Hb) haemoglobin using near-infrared light, which penetrates biological tissues.

Methods

Normal subjects and patients with depression and anxiety (DSM-IV) were examined by NeuroBek-NIRS (NBCW-IR10), a multichannel near-infrared spectroscopy (ten channels) with Continuous Wave (CW) source which allows human subjects to observe and control changes of their own blood oxygen level-dependent (BOLD) response. NBS-RTsys 64-channel-resolved-optical-tomographic-imaging is used with the following technical parameters : gain of 10,000, filters pass-band between 0,3-30 Hz, 60 Hz "notch" filter of noise $2\mu\text{V}$ RMS. EEGs were recorded from the 16 electrode site of the international 10-20 system while the subjects were at rest with their eyes closed. New algorithms were developed to estimate alterations of oxyhaemoglobin (oxy-Hb), some deoxyhaemoglobin (deoxy-Hb) and Total haemoglobin (HbT) during the performance of cognitive tasks. Plus, verbal repetition task, verbal fluency test, T.O.V.A and MicroCog were performed. Fronto-parieto-occipito-temporal (Fp1-Fp2-P3-P4-01-02-T3-T4) regions were measured. Skin conductance response (SCR) was examined too.

Results

Significantly enhance SCR and oxy-Hb in fronto-orbital region during Microcog's task in depressed patients; deoxy-Hb decrease compared with the control group. Correlations at $p < .01$. between qEEG/ERPs and NBCW-IR10 were observed. Statistical significance was defined as $p < 0.005$, difference statistically significant $p < 0.001$.

Conclusions

The functional BOLD NIRS is a promising method for serial non-invasive bedside CBF measurements. This

method can offer therapeutic possibilities in certain cases an alternative, a relay and a complement in aid of medicines.