A Selection of Neurotherapy Study Abstracts

Neurofeedback for Children with ADHD: A Comparison of SCP and Theta/Beta Protocols

Journal	Applied Psychophysiology and Biofeedback
Publisher	Springer Netherlands
ISSN	1090-0586 (Print) 1573-3270 (Online)
Issue	Volume 32, Number 2 / June, 2007
Category	Original Paper
DOI	10.1007/s10484-007-9031-0
Pages	73-88
Subject Collection	Behavioral Science
SpringerLink Date	Wednesday, March 14, 2007

Ulrike Leins[1], Gabriella Goth[2], Thilo Hinterberger[2], Christoph Klinger[2], Nicola Rumpf[2] and Ute Strehl[2]

(1) Department of Psychiatry and Psychotherapy, University Hospital of Tübingen, Osianderstrasse 24, 72076 Tübingen, Germany

(2) Institute of Medical Psychology and Behavioral Neurobiology, University of Tübingen, Tübingen, Germany

Received: 20 July 2006 **Accepted:** 7 February 2007 **Published online:** 14 March 2007

Abstract Behavioral and cognitive improvements in children with ADHD have been consistently reported after neurofeedback-treatment. However, neurofeedback has not been commonly accepted as a treatment for ADHD. This study addresses previous methodological shortcomings while comparing a neurofeedback-training of Theta-Beta frequencies and training of slow cortical potentials (SCPs). The study aimed at answering (a) whether patients were able to demonstrate learning of cortical self-regulation, (b) if treatment leads to an improvement in cognition and behavior and (c) if the two experimental groups differ in cognitive and behavioral outcome variables. SCP participants were trained to produce positive and negative SCP-shifts while the Theta/Beta participants were trained to suppress Theta (4–8 Hz) while increasing Beta (12–20 Hz). Participants were blind to group assignment. Assessment included potentially confounding variables. Each group was comprised of 19 children with ADHD (aged 8–13 years). The treatment procedure consisted of three phases of 10 sessions each. Both groups were able to intentionally regulate cortical activity and improved in attention and IQ. Parents and teachers reported significant behavioral and

cognitive improvements. Clinical effects for both groups remained stable six months after treatment. Groups did not differ in behavioural or cognitive outcome.

**

Evaluation of the effectiveness of EEG neurofeedback training for ADHD in a clinical setting as measured by changes in T.O.V.A. scores, behavioral ratings, and WISC-R performance

Journal	Applied Psychophysiology and Biofeedback
Publisher	Springer Netherlands
ISSN	1090-0586 (Print) 1573-3270 (Online)
Issue	Volume 20, Number 1 / March, 1995
DOI	10.1007/BF01712768
Pages	83-99
Subject Collection	Behavioral Science
SpringerLink Date	Monday, June 20, 2005

Joel F. Lubar[1], Michie Odle Swartwood[1], Jeffery N. Swartwood[1] and Phyllis H. O'Donnell[1]

(1) University of Tennessee, 310 Austin Peay Building, 37996-0900 Knoxville, Tennessee, USA

Abstract A study with three component parts was performed to assess the effectiveness of neurofeedback treatment for Attention Deficit/Hyperactivity Disorder (ADHD). The subject pool consisted of 23 children and adolescents ranging in age from 8 to 19 years with a mean of 11.4 years who participated in a 2-to 3-month summer program of intensive neurofeedback training. Feedback was contingent on the production of 16–20 hertz (beta) activity in the absence of 4–8 hertz (theta) activity. Posttraining changes in EEG activity, T.O.V.A. performance, (ADDES) behavior ratings, and WISC-R performance were assessed. Part I indicated that subjects who successfully decreased theta activity showed significant improvement in T.O.V.A. performance; Part II revealed significant improvement in parent ratings following neurofeedback training; and Part III indicated significant increases in WISC-R scores following neurofeedback training. This study is significant in that it examines the effects of neurofeedback training on both objective and subjective measures under relatively controlled conditions. Our findings corroborate and extend previous research, indicating that neurofeedback training can be an appropriate and efficacious treatment for children with ADHD.

**

. Neocortical Dynamics: Implications for Understanding the Role of Neurofeedback and Related Techniques for the Enhancement of Attention

Journal	Applied Psychophysiology and Biofeedback
Publisher	Springer Netherlands
ISSN	1090-0586 (Print) 1573-3270 (Online)
Issue	Volume 22, Number 2 / June, 1997
DOI	10.1023/A:1026276228832
Pages	111-126
Subject Collection	Behavioral Science
SpringerLink Date	Monday, November 29, 2004

Joel F. Lubar[1]

(1) Department of Psychology, University of Tennessee, Knoxville, Tennessee, 37996-0900

Abstract *For nearly 25 years, EEG biofeedback (neurofeedback) has been utilized in research and clinical settings for the treatment and investigation of a number of disorders ranging from attention deficit hyperactivity disorder to seizure disorders as well as many other established and investigational applications. Until recently, mechanisms underlying the generation and origins of EEG have been poorly understood but now are beginning to become much more clarified. Now it is important to combine the information gathered on the genesis of EEG and neocortical dynamics with the findings from neurofeedback investigations. This will help us to develop models of how neurofeedback might operate in producing the changes in EEG and in clinical symptomatology. We know that the cortex operates in terms of resonant loops between neocortical columns of cells known as local, regional, and global resonances. These resonances determine the specific EEG frequencies and are often activated by groups of cells in the thalamus known as pacemakers. There are complex excitatory and inhibitory interactions within the cortex and between the cortex and the thalamus that allow these loops to operate and provide the basis for learning. Neurofeedback is a technique for modifying these resonant loops, and hence, modifying the neurophysiological and neurological basis for learning and for the management of a number of neurologically based disorders. This paper provides an introduction to understanding EEG and neocortical dynamics and how these concepts can be used to explain the results of neurofeedback training and other interventions particularly in the context of understanding attentive mechanisms and for the management of attention deficit/hyperactivity disorders.*

**

. Neurofeedback Treatment for Attention-Deficit/Hyperactivity Disorder in Children: A Comparison with Methylphenidate

Journal	Applied Psychophysiology and Biofeedback
Publisher	Springer Netherlands
ISSN	1090-0586 (Print) 1573-3270 (Online)
Issue	Volume 28, Number 1 / March, 2003
DOI	10.1023/A:1022353731579
Pages	1-12
Subject Collection	Behavioral Science
SpringerLink Date	Tuesday, November 02, 2004

Thomas Fuchs[1], Niels Birbaumer[1, 2], Werner Lutzenberger[1], John H. Gruzelier[3] and Jochen Kaiser[1]

(1) Institute of Medical Psychology and Behavioral Neurobiology, Eberhard-Karls-University of Tübingen, Germany

(2) Institute of Cognitive Neuroscience, University of Trento, Italy

(3) Department of Behavioral and Cognitive Science, Imperial College School of Medicine, London, United Kingdom

Abstract Clinical trials have suggested that neurofeedback may be efficient in treating attention-deficit/hyperactivity disorder (ADHD). We compared the effects of a 3-month electroencephalographic feedback program providing reinforcement contingent on the production of cortical sensorimotor rhythm (12–15 Hz) and beta1 activity (15–18 Hz) with stimulant medication. Participants were *N* = 34 children aged 8–12 years, 22 of which were assigned to the neurofeedback group and 12 to the methylphenidate group according to their parents' preference. Both neurofeedback and methylphenidate were associated with improvements on all subscales of the Test of Variables of Attention, and on the speed and accuracy measures of the d2 Attention Endurance Test. Furthermore, behaviors related to the disorder were rated as significantly reduced in both groups by both teachers and parents on the IOWA-Conners Behavior Rating Scale. These findings suggest that neurofeedback was efficient in improving some of the behavioral concomitants of ADHD in children whose parents favored a nonpharmacological treatment.

**

Neurofeedback Combined with Training in Metacognitive Strategies: Effectiveness in Students with ADD

Journal	Applied Psychophysiology and Biofeedback

Publisher	Springer Netherlands
ISSN	1090-0586 (Print) 1573-3270 (Online)
Issue	Volume 23, Number 4 / December, 1998
DOI	10.1023/A:1022213731956
Pages	243-263
Subject Collection	Behavioral Science
SpringerLink Date	Thursday, October 28, 2004

L. Thompson[1] and M. Thompson[1]

(1) ADD Centre, Mississauga, Ontario, Canada

Abstract *A review of records was carried out to examine the results obtained when people with Attention Deficit Disorder (ADD) received 40 sessions of training that combined neurofeedback with the teaching of metacognitive strategies. While not a controlled scientific study, the results, including pre- and post-measures, are consistent with previously published research concerning the use of neurofeedback with children. A significant addition is that a description of procedures is included. The 111 subjects, 98 children (age 5 to 17) and 13 adults (ages 18 to 63), attended forty 50-min sessions, usually twice a week. Feedback was contingent on decreasing slow wave activity (usually 4–7 Hz, occasionally 9–11 Hz) and increasing fast wave activity (15–18 Hz for most subjects but initially 13–15 Hz for subjects with impulsivity and hyperactivity). Metacognitive strategies related to academic tasks were taught when the feedback indicated the client was focused. Some clients also received temperature and/or EDR biofeedback during some sessions. Initially, 30 percent of the children were taking stimulant medications (Ritalin), whereas 6 percent were on stimulant medications after 40 sessions. All charts were included where pre- and post-testing results were available for one or more of the following: the Test of Variables of Attention (TOVA,* n=76*), Wechsler Intelligence Scales (WISC-R, WISC-III, or WA1S-R,* n=68*), Wide Range Achievement Test (WRAT 3,* n=99*), and the electroencephalogram assessment (QEEG) providing a ratio of theta (4–8 Hz) to beta (16–20 Hz) activity (*n=66*). Significant improvements (*p<.001*) were found in ADD symptoms (inattention, impulsivity, and variability of response times on the TOVA), in both the ACID pattern and the full-scale scores of the Wechsler Intelligence Scales, and in academic performance on the WRAT 3. The average gain for the full scale IQ equivalent score was 12 points. A decrease in the EEG ratio of theta/beta was also observed. These data are important because they provide an extension of results from earlier studies (Lubar, Swartwood, Swartwood, & O'Donnell, 1995; Linden, Habib, & Radojevic, 1996). They also demonstrate that systematic data collection in a private educational setting produces helpful information that can be used to monitor students' progress and improve programs. Because this clinical work is not a controlled scientific study, the efficacious treatment components cannot be determined. Nevertheless, the positive outcomes of decreased ADD symptoms plus*

improved academic and intellectual functioning suggest that the use of neurofeedback plus training in metacognitive strategies is a useful combined intervention for students with ADD. Further controlled research is warranted.

The effect of training distinct neurofeedback protocols on aspects of cognitive performance

David Vernon, **Tobias Egner, Nick Cooper, Theresa Compton, Claire Neilands, Amna Sheri and John Gruzelier**

Department of Cognitive Neuroscience and Behaviour, Imperial College London, Charing Cross Hospital, St. Dunstans Road, London W6 8RF, UK

Received 5 August 2002; revised 14 August 2002; accepted 15 August 2002. ; Available online 11 October 2002.

Abstract

The use of neurofeedback as an operant conditioning paradigm has disclosed that participants are able to gain some control over particular aspects of their electroencephalogram (EEG). Based on the association between theta activity (4–7 Hz) and working memory performance, and sensorimotor rhythm (SMR) activity (12–15 Hz) and attentional processing, we investigated the possibility that training healthy individuals to enhance either of these frequencies would specifically influence a particular aspect of cognitive performance, relative to a non-neurofeedback control-group. The results revealed that after eight sessions of neurofeedback the SMR-group were able to selectively enhance their SMR activity, as indexed by increased SMR/theta and SMR/beta ratios. In contrast, those trained to selectively enhance theta activity failed to exhibit any changes in their EEG. Furthermore, the SMR-group exhibited a significant and clear improvement in cued recall performance, using a semantic working memory task, and to a lesser extent showed improved accuracy of focused attentional processing using a 2-sequence continuous performance task. This suggests that normal healthy individuals can learn to increase a specific component of their EEG activity, and that such enhanced activity may facilitate semantic processing in a working memory task and

to a lesser extent focused attention. We discuss possible mechanisms that could mediate such effects and indicate a number of directions for future research.

**

Ecological validity of neurofeedback: modulation of slow wave EEG enhances musical performance.

COGNITIVE NEUROSCIENCE AND NEUROPSYCHOLOGY

Neuroreport. 14(9):1221-1224, July 1, 2003.
Egner, Tobias; Gruzelier, John H

Abstract:
Biofeedback-assisted modulation of electrocortical activity has been established to have intrinsic clinical benefits and has been shown to improve cognitive performance in healthy humans. In order to further investigate the pedagogic relevance of electroencephalograph (EEG) biofeedback (neurofeedback) for enhancing normal function, a series of investigations assessed the training's impact on an ecologically valid real-life behavioural performance measure: music performance under stressful conditions in conservatoire students. In a pilot study, single-blind expert ratings documented improvements in musical performance in a student group that received training on attention and relaxation related neurofeedback protocols, and improvements were highly correlated with learning to progressively raise theta (5-8 Hz) over alpha (8-11 Hz) band amplitudes. These findings were replicated in a second experiment where an alpha/theta training group displayed significant performance enhancement not found with other neurofeedback training protocols or in alternative interventions, including the widely applied Alexander technique.

**

Functional MRI for neurofeedback: feasibility study on a hand motor task.

Regeneration And Transplantation

Neuroreport. 13(11):1377-1381, August 7, 2002.
Yoo, Seung-Schik CA; Jolesz, Ferenc A.

Abstract:
We present an fMRI-based method that enables subjects to monitor and actively modulate their own brain activity as a form of biofeedback. On a 1.5 T clinical MR scanner, functional areas during a simple hand motor task were delineated by

detecting signal variations associated with the brain activity. Then, the subject adopted a different strategy to expand the activation in motor and somatosensory areas that were not activated previously. Statistical maps of brain activity were visually presented back to the subject, being updated at the end of each segmented rest-task block in near real-time manner. Our results suggest that the visual feedback of the functional brain activation maps guided subjects to adjust their task performance to achieve the desired modulation of cortical activity. This method may offer a potential utility for fMRI-based neurofeedback.

Experiences of using neurofeedback in clinical practice

M. Sygut[1], K. Czech[2], K. Krysta[1], I. Krupka-Matuszczyk[1] and A. Klasik[1]

[1]Department of Psychiatry and Psychotherapy, Medical University of Silesia, Katowice, Poland

[2]Department of Cinical and Forensic Psychology, Silesian University, Katowice, Poland

P382. Available online 16 February 2007.

European Psychiatry
Volume 22, Supplement 1, March 2007, Pages S209-S210
15th AEP Congress - Abstract book, 15th AEP Congress

**

What is Neurofeedback&#63

Author: Hammond, D. C.[1]
Source: Journal of Neurotherapy, Volume 10, Number 4, 29 March 2007 , pp. 25-36(12)
Publisher: Haworth Press

Abstract:
EEG biofeedback (neurofeedback) originated in the late 1960s as a method for retraining brainwave patterns through operant conditioning. Since that time a sizable body of research has accumulated on the effectiveness of neurofeedback in the treatment of uncontrolled epilepsy, ADD/ADHD, anxiety, alcoholism, posttraumatic stress disorder, and mild head injuries. Studies also provide encouraging indications that neurofeedback offers a treatment alternative for use with learning disabilities, stroke, depression, fibromyalgia, autism, insomnia, tinnitus, headaches, problems with physical balance, and for the enhancement of peak performance. At a time when an increasing number of people are concerned with negative effects from relying solely on medication treatments, neurofeedback may offer an additional treatment alternative for many conditions. This article assists the reader to understand how neurofeedback works, how assessment allows neurofeedback to be individualized, and briefly reviews evidence for the neurofeedback treatment of many conditions. The public is cautioned that in selecting a practitioner for the treatment of the kinds of medical, psychiatric and psychological conditions cited above, a practitioner should be licensed for independent practice in their state or province and should ideally also be certified by a legitimately recognized body. doi:10.1300/J184v10n04_04

**

Neurofeedback for ADHD

Posted 02/28/2007

Barbara Geller, MD
Author Information

Neurofeedback could be an effective and enduring nonpharmacologic treatment.

Summary

In several small, open-treatment case series starting in the 1970s, children with ADHD benefited from EEG biofeedback. These researchers examined EEG data during biofeedback training of 23 children with DSM-IV ADHD inattentive, hyperactive, or combined types (age range, 8–13; 19 boys). Behavior, cognition, and quality of life were also assessed.

The training involved three phases of 10 sessions each. Phases, which lasted 2 weeks, were separated by 4 to 6 weeks. The children were trained to control event-related slow cortical potentials (SCPs). Initially, both auditory and visual feedback was given (e.g., a computer screen showed a ball moving proportionally with the direction of the SCP, and smiley faces appeared when SCP regulation increased). Cognitive exercises without biofeedback were used for practice between sessions and after training.

At the end of treatment, children improved their regulation of negative SCPs. Teacher- and parent-rated behavioral problems were reduced. The improved regulation and behavior were still evident 6 months after training had ended.

Comment

The concept behind this intriguing work is highly reasonable. The availability of nonpharmacologic modalities for treating the highly prevalent ADHD syndromes would certainly be important. The techniques seem user-friendly -- no child dropped out because of technical adversity. The authors note that similar feedback on both positive and negative cortical potentials has been useful for patients with certain seizure disorders.

The study's main drawback is the lack of controls and blinded raters. The authors contend these are not possible in this type of research. However, using time with supportive adults and similar cognitive tasks without EEG feedback as controls would be informative.

**

Controlled evaluation of a neurofeedback training of slow cortical potentials in children with Attention Deficit/Hyperactivity Disorder (ADHD).

Authors:

Drechsler, R C
Straub, M
Doehnert, M A
Heinrich, H
Steinhausen, H C
Brandeis,D

Issue Date:

2007

Publisher:

BioMed Central

Citation:

Behav Brain Funct 2007, 3(1):35

Abstract:
BACKGROUND: Although several promising studies on neurofeedback training in Attention Deficit/Hyperactivity Disorder (ADHD) have been performed in recent years, the specificity of positive treatment effects continues to be challenged. METHODS: To evaluate the specificity of a neurofeedback training of slow cortical potentials, a twofold strategy was pursued: First, the efficacy of neurofeedback training was compared to a group training program for children with ADHD. Secondly, the extent of improvements observed in the neurofeedback group in relation to successful regulation of cortical activation was examined. Parents and teachers rated children's behaviour and executive functions before and after treatment. In addition, children underwent neuropsychological testing before and after training. RESULTS: According to parents' and teachers' ratings, children of the neurofeedback training group improved more than children who had participated in a group therapy program, particularly in att...

URI:

http://hdl.handle.net/2379/13239

ISSN:

1744-9081

PubMed ID:

17655749

DOI:

10.1186/1744-9081-3-35

Type:

Article

**

Computational Intelligence and Neuroscience

Volume 2007 (2007), Article ID 94561, 9 pages

doi:10.1155/2007/94561

Research Article

Fully Online Multicommand Brain-Computer Interface with Visual Neurofeedback Using SSVEP Paradigm

Pablo Martinez, Hovagim Bakardjian, **and** Andrzej Cichocki

Laboratory for Advanced Brain Signal Processing, Brain Science Institute RIKEN, Wako-Shi, Saitama 351-0198, Japan

Received 22 December 2006; Accepted 22 May 2007

Recommended by Fabio Babiloni

We propose a new multistage procedure for a real-time brain-machine/computer interface (BCI). The developed system allows a BCI user to navigate a small car (or any other

object) on the computer screen in real time, in any of the four directions, and to stop it if necessary. Extensive experiments with five young healthy subjects confirmed the high performance of the proposed online BCI system. The modular structure, high speed, and the optimal frequency band characteristics of the BCI platform are features which allow an extension to a substantially higher number of commands in the near future.

This article was published in the special issue "Brain-Computer Interfaces: Towards Practical Implementations and Potential Applications" edited by Fabio Babiloni, Andrzej Cichocki, and Shangkai Gao.

**

THE EFFECTS OF NEUROFEEDBACK TRAINING IN THE COGNITIVE DIVISION OF THE ANTERIOR CINGULATE GYRUS

Authors: Rex Cannon [a]; Joel Lubar [b]; Marco Congedo [c]; Keri Thornton [b]; Kerry Towler [d]; Teresa Hutchens [e]

Affiliations: [a] Psychology Program, University of Tennessee Brain Research and Neuropsychology Lab, Knoxville, Tennessee, USA
[b] University of Tennessee, Knoxville, Tennessee, USA
[c] France Telecom R&D, Meylan, France
[d] Experimental Psychology Program, University of Tennessee, Knoxville, Tennessee, USA
[e] Department of Psychology, University of Tennessee, Knoxville, Tennessee, USA

DOI: 10.1080/00207450500514003
Publication Frequency: 12 issues per year
Published in: International Journal of Neuroscience, Volume 117, Issue 3 March 2007 , pages 337 - 357
Subject: Neuroscience;
Formats available: HTML (English) : PDF (English)

Abstract

This study examines the efficacy of neurofeedback training in the cognitive division of the anterior cingulate gyrus and describes its relationship with cortical regions known to be involved in executive functions. This study was conducted with eight non-clinical students, four male and four female, with a mean age of twenty-two. Learning occurred in the ACcd at significant levels over sessions and in the anterior regions that receive projections from the AC. There appears to be a multidimensional executive circuit that increases in the same frequency in apparent synchrony with the AC and it may be possible to train this sub-cortical region using LNFB.

**

EEG Neurofeedback: A Brief Overview and an Example of Peak Alpha Frequency Training for Cognitive Enhancement in the Elderly

Authors: Efthymios Angelakis [a]; Stamatina Stathopoulou [a]; Jennifer L. Frymiare [b]; Deborah L. Green [a]; Joel F. Lubar [c]; John Kounios [a]

Affiliations: [a] Department of Psychology, Drexel University, Philadelphia, PA

[b] Department of Psychology, University of Wisconsin-Madison, Madison, WI

[c] Department of Psychology, University of Tennessee, Knoxville, TN, USA

DOI: 10.1080/13854040600744839

Publication Frequency: 4 issues per year

Published in: The Clinical Neuropsychologist, Volume 21, Issue 1 January 2007 , pages 110 - 129

Subject: Neuropsychology;

Formats available: HTML (English) : PDF (English)

•

Abstract

Neurofeedback (NF) is an electroencephalographic (EEG) biofeedback technique for training individuals to alter their brain activity via operant conditioning. Research has shown that NF helps reduce symptoms of several neurological and psychiatric disorders, with ongoing research currently investigating applications to other disorders and to the enhancement of non-disordered cognition. The present article briefly reviews the fundamentals and current status of NF therapy and research and illustrates the basic approach with an interim report on a pilot study aimed at developing a new NF protocol for improving cognitive function in the elderly. EEG peak alpha frequency (PAF) has been shown to correlate positively with cognitive performance and to correlate negatively with age after childhood. The present pilot study used a double-blind controlled design to investigate whether training older individuals to increase PAF would result in improved cognitive performance. The results suggested that PAF NF improved cognitive processing speed and executive function, but that it had no clear effect on memory. In sum, the results suggest that the PAF NF protocol is a promising technique for improving selected cognitive functions.

**

Neurofeedback Gaming for Wellbeing

Joran van Aart, Eelco Klaver, Christoph Bartneck, Loe Feijs, Peter Peters
Department of Industrial Design, Eindhoven University of Technology
Den Dolech 2, P.O. Box 513, 5600 MB Eindhoven, The Netherlands
design@joran.eu, e.r.g.klaver@student.tue.nl, {c.bartneck, l.m.g.feijs; p.j.f.peters} @ tue.nl

ABSTRACT

In this paper we discuss our vision on future neurofeedback therapy. We analyze problems of the current situation and debate for a change in focus towards a vision in which neurofeedback therapy will ultimately be as easy as taking an aspirin. Furthermore we argue for a gaming approach as training, for separation between neurofeedback therapy and gaming has become noticeably smaller after recent development in brain manipulated interfaces. We conclude by providing suggestions of how to achieve this vision.

**

Neurofeedback as a Treatment for ADHD: A Methodological Review with Implications for Future Research

Authors: Vernon, David[1]; Frick, Ann[2]; Gruzelier, John[2]

Source: Journal of Neurotherapy, Volume 8, Number 2, 11 May 2004 , pp. 53-82(30)
Publisher: Haworth Press

Abstract:
Attention deficit/hyperactivity disorder (ADHD) represents one of the most common psychiatric disorders in childhood, resulting in serious impairment across a variety of domains. Research showing that a high proportion of children with ADHD exhibit a dysfunctional electroencephalogram (EEG), relative to aged matched peers, provides a rationale for the use of neurofeedback as an intervention. The aim of neurofeedback training is to redress any EEG abnormality, resulting in a concomitant improvement in the behaviour and/or cognitive performance of these children. This review focused on studies using neurofeedback to treat children with ADHD, with particular emphasis on the methodological aspects of neurofeedback training. Specifically, the review examined the modality of feedback provided, the different training parameters and their underlying rationale, and the particular montages used. In addition, the review also focused on the duration, frequency and total number of training sessions required to obtain a positive effect in terms of a change in the individual's EEG, behaviour and/or cognitive performance. Finally, the long-term effects of neurofeedback and the potential negative side effects were reviewed. Throughout, the review provides a number of directions for future research.

**

Using individual EEG peculiarities increase neurofeedback efficiency

Olga Bazanova[1] and **Lubomir Aftanas**[2]

[1]Institute of Molecular Biology and Biophysics, Russian Federation
[2]State-Research Institute of Clinical Immunology SB RAMS, Russian Federation
corresponding author email

from International Society on Brain and Behaviour: 2nd International Congress on Brain and Behaviour
Thessaloniki, Greece. 17–20 November 2005

Annals of General Psychiatry 2006, **5**(Suppl 1)**:**S98doi:10.1186/1744-859X-5-S1-S98

Published: 28 February 2006

Background

The "alpha rhythm" had large sinusoidal waveforms at a rate around 10 cycles per second against a background of smaller waves, "waves of the second order" (i.e., beta). Alpha waves were pronounced in posterior regions during eyes closed resting states, and diminished markedly upon opening the eyes.

This is how the alpha rhythm was defined 70 years ago. Today we have a superior definition: Alpha activity occurs between 8 and 13 Hz, or is it between 8 and 12 Hz, or perhaps 7 and 13 Hz, or 7.81 and 14.06 Hz, or 8 and 15 Hz (Etevenon *et al*., 1990, Ray and Cole, 1985). What is more disturbing than the different intervals are their boundaries, which are artificial, a product of ease of communication and the limits of one's analytical technique. The alpha rhythm is defined as the dominant frequency rhythm in the resting state, the frequency band that dominates the spectral density distribution. At this scale the brain rarely uses integers. Perhaps we would do better to keep the names simple but not its designation.

Klimesh (1999) developed a simple designation strategy; he identifies an individual alpha frequency (IAF) from each subject, then defines bands relative to this peak. Lower alpha is from 2.5 Hz below IAF up to IAF, and higher alpha runs from IAF to IAF plus 2.5 Hz. The theta band is also defined relative to IAF. Obviously the plus or minus 2.5 Hz is artificial and is one of those compromises plentiful to psychophysiology, based on empirical data and ease. Some subjects will have a narrow dominant frequency, others might hit the mark exactly. Perhaps a refinement of the formula is needed, a mixture of percent attenuation and topography. This might produce a truly customized dominant frequency bandwidth. From there we build towards the otherbandwidths of interest. Eventually we may find out that restricting our analysis to such unique ranges can improve the reliability and validity of our conclusions.

Materials and methods

The hypothesis was tested of whether neurofeedback training applied in order to increase or decrease power of individual EEG frequency ranges is more efficient than neurofeedback training of standard EEG frequency ranges. The sessions of theta/beta decreasing and alpha stimulating trainings were carried out on two outpatients with attention deficit disorder (the schoolboy) and functional pain contraction (professional musician).

Results

The neurofeedback with standard frequency ranges was inefficient and even resulted in aggravation of symptoms of disorders in both cases. The neurofeedback training with individual frequency ranges resulted in substantial clinical improvement.

Discussion

The large variance in peak and width begs the question: why do we use a large band to assess dominant frequency activity? Would it not be simple to calculate an IAF, even with a one-channel EEG system? These three properties align to produce the most regular and consistent recording possible in human EEG. We are all aware of frontal slowing in ADHD children. Some argue convincingly that high theta activity in such a population is actually misnamed; it is merely an immature manifestation of the alpha rhythm (the child's dominant frequency). So 4–7 Hz may be theta for some and alpha for others. Analogy can be noted for persons with IAF more then 11 Hz. Statistical descriptions may be powerful and accurate tools, but rarely as powerful as individual data (Kaiser, 2001).

References

1. Etevenon P, Bertaut A, Mitermite F, Eustache F, Lepaisant J, Lechevalier B, Zarifian E: **Inter- and intra-individual probability maps in EEG cartography by use of nonparametric Fisher tests.**
   Brain Topogr 1989, **2:**81-89. PubMed Abstract | Publisher Full Text |
   Return to text
2. Klimesh W:
   Quantization Considerations for Distortion-Controlled Data Compression, TMO PR 42–139, July–September 1999.1-38.
   November 15, 1999

Return to text

3. Ray WJ, Cole HW: **EEG activity during cognitive processing: influence of attentional factors.**
Int J Psychophysiol 1985, **3:**43-48. PubMed Abstract | Publisher Full Text |
Return to text

4. Kaiser DA: **Rethinking Standard Bands.**
J Neurotherapy 2001, **5:**96.
Return to text

**

Neurofeedback for Elementary Students with Identified Learning Problems

Authors: Orlando, Peter[1]; Rivera, Richard O.[2]
Source: Journal of Neurotherapy, Volume 8, Number 2, 11 May 2004 , pp. 5-19(15)
Publisher: Haworth Press

Abstract:
Introduction. The goal of this research was to ascertain whether basic reading, reading comprehension, the reading composite, and IQ scores could be improved using neurofeedback. Pre-test and post-test reading and cognitive assessments were administered to sixth, seventh and eighth graders identified as having learning problems. Control and experimental groups were chosen at random. With the exception of three students, every student in the control and experimental group had previously been diagnosed with Specific Learning Disabilities or as Other Health Impaired according to State and Federal guidelines for special education services. The three students were medically diagnosed as having ADHD and were on a 504 Accommodation Plan. Method. The research began in late August 2001 with securing administrative and parental permissions. Student participation began during the last week in September and lasted through the last week in April. A day was set aside to administer QEEGs (also called brain maps) to the students in the experimental group. Protocols were developed by following the brain maps and by using clinical judgment after staffing the students with their teachers on a regular basis; their psychoeducational evaluations were also used to plan the protocols. Following the statistics on the biofeedback machines also influenced protocol decisions. Neurofeedback training was provided to the participants of the experimental group only. Both the experimental group and the control group had their Individualized Educational Plans (IEP) or 504 Plans plus their general curriculum plans. Neurofeedback training lasted approximately 30 to 45 minutes within each one-hour time block. The sessions were conducted weekly for the seven-month period. Some students received more sessions than others because of absences, field trips, testing and other natural rhythms of home and school life. The average number of sessions per student was 28. Results. Neurofeedback was more effective in improving reading tests than no neurofeedback training. There were significant interactions between neurofeedback and time on basic reading. Wilks' lambda (Ë)=.69,F(1, 23) = 10.32, p < .01, on reading comprehension,λ= .75, F(1, 23) = 7.62, p = .01, and on reading composite scores, ,λ= .65, F(1, 23) = 12.59, p < .01. Neurofeedback training was more effective in improving both the Verbal and Full Scale IQ scores than no neurofeedback training. There was a significant interaction between neurofeedback and time on Verbal IQ, λ= .62, F(1, 21) = 12.71, p < .01, and on Full Scale IQ, λ= .56, F(1, 21) = 16.50, p < .01. However, there was not a significant interaction between neurofeedback and time on Performance IQ, λ= .87, F(1, 21) = 3.00, p = .10. Discussion. The results support the hypothesis that biofeedback training is effective in improving reading quotients. Limitations of the study and ideas for further research are presented. Neurofeedback may be an effective supplement to special education in improving IQ and reading performance.

**

Neurofeedback with Juvenile Offenders A Pilot Study in the Use of QEEG-Based and Analog-Based Remedial Neurofeedback Training

Authors: Smith, Peter N.[1]; Sams, Marvin W.[2]
Source: Journal of Neurotherapy, Volume 9, Number 3, 23 May 2006 , pp. 87-99(13)
Publisher: Haworth Press

Abstract:
Introduction. Atypical EEG and neuropsychological indicators have been observed among offenders. Dangerous offenders treated with a combined program that included neurofeedback (EEG biofeedback) and galvanic skin response (GSR) biofeedback demonstrated reduction in recidivism (Quirk, 1995). This study was designed to further evaluate the EEG findings of youth offenders and to provide an initial report on the effectiveness of a task oriented analog/ QEEG-based remedial neurofeedback training approach. Method. Five offenders with significant psychopathology were referred for treatment. The group was evaluated with attentional testing and analog/QEEG assessment prior to and following neurotherapy. Treatment consisted of 20 or 40 sessions of a task-activated, analog/QEEG-based approach. Another group of thirteen offenders were assessed with attentional testing and provided with neurotherapy following QEEG assessment. Results. For all of the youth trained, in the analog/QEEG group, prevs. post-audio and visual attention testing demonstrated significant improvement within 20 remedial sessions. Three of the five youth showed rapid advancement in a residential grading system. Staff observational ratings suggested behavioral improvement in the QEEG group who in general were in training for a longer period of time. Conclusion. EEG abnormalities and deficits in neuropsychological testing were found among offenders. Neurotherapy as an adjunctive treatment appears to hold promise for improvement in cognitive performance as well as recidivism. It is anticipated that different neurofeedback protocols may enhance outcomes.

**

Case Study of Trigeminal Neuralgia Using Neurofeedback and Peripheral Biofeedback

Abstract:
Background. Trigeminal neuralgia is characterized by brief episodes of extremely intense facial pain often radiating down the jaw. These episodes can occur spontaneously or be triggered by light touch, chewing or changes in temperature. The pain can be so intense as to be completely disabling. This case study concerns a 46 year-old nurse with a 15-month history of trigeminal neuralgia. She had been maintained poorly on Propoxyphene/apap100/650 mg (100 mg Darvocet with 650 mg acetaminophen) over the previous year. Her neurologist's next planned intervention was to sever the trigeminal nerve. Method. Over a period of nine months, this client had 10 peripheral biofeedback training sessions (including dynamic EMG biofeedback) and diaphragmatic breathing in conjunction with a program of stress management and counseling. She also received 29 sessions of neurofeedback (including T4, C3, C4, C3-C4 and T3-T4). C3 seemed to be the most effective placement for sleep maintenance issues, and T3-T4 seemed to be the most effective placement for pain issues. Results. The client experienced a substantial reduction in pain and bruxism as well as improvement in sleep quality. Symptom reduction fluctuated with life stress issues and with adjustment in both peripheral and neurofeedback protocols. The success of this treatment allowed the client to avoid radical surgery (severing of the trigeminal nerve) and to discontinue use of Propoxyphene/apap 100/650 mg. In a 13-month follow- up, the client reports having an active life style and managing her pain quite well on 20 mg of tramadol hydrochloride (Ultram) every 12 hours as long as she uses her self-regulation techniques. Conclusion. This case study suggests that a multi-modal approach of neurofeedback, peripheral biofeedback, stress management and counseling was clinically efficacious in treating the symptoms of this difficult and painful condition.

**

The Low Energy Neurofeedback System (LENS): Theory, Background, and Introduction

Author: Ochs, Len[1]
Source: Journal of Neurotherapy, Volume 10, Numbers 2-3, 27 December 2006 , pp. 5-39(35)
Publisher: Haworth Press
Abstract:
This article presents the concepts, operations, and history of the Low Energy Neurofeedback System (LENS) approach as they are now known and as it has evolved over the past 16 years. The conceptual bases and practical operating principles as described are quite different from those in traditional neurofeedback. The LENS, as a behavioral neurofeedback application, often provides the same qualitative outcome as that in traditional neurofeedback, with reduced treatment time. doi:10.1300/J184v10n02_02

**

Neurofeedback Treatment of Two Children with Learning, Attention, Mood, Social, and Developmental Deficits

Author: Jacobs, Edward H.[1]
Source: Journal of Neurotherapy, Volume 9, Number 4, 18 July 2006 , pp. 55-70(16)
Publisher: Haworth Press
Abstract:
Background. Neurofeedback is biofeedback training of EEG activity through an operant conditioning process by which the individual is trained to increase or inhibit the brain's production of electrical activity in specific frequency ranges. Studies have demonstrated efficacy with a variety of disorders, including attention deficit hyperactivity disorder (ADHD), learning problems, and autistic features. This paper describes the application of neurofeedback in a clinical setting with two complex children who manifested multiple diagnoses, including learning disabilities (LD), ADHD, social deficits, mood disorders, and pervasive developmental disorder (PDD). Both boys had adjusted poorly to school, family, and peers. Methods. Subjects were referred to the author's clinical practice. They received individualized protocols based on their symptoms and functional impairments. They were administered semi-weekly 20-minute sessions of one-channel neurofeedback training for approximately six months. In both cases symptoms were identified and tracked with a parent rating scale and one case, with the Symptom Assessment-45 Questionnaire (SA-45) also. Results. Each boy improved in all tracked symptoms without adverse effects. One improved on most measures of the SA-45 with no deterioration on any measure. Functional improvements in academic functioning, home behavior, and peer relationships were indicated. Conclusions. Neurofeedback was a successful treatment for these two multi-symptomatic and diagnosed boys, whose improvements surpassed the gainsmade with previous therapies. The advantages of neurofeedback include the relative absence of observable adverse effects, the lack of reliance on medication with its possible side effects and noncompliance, and the possibility of long-term gains without continued intervention.

**

Neurofeedback to Improve Physical Balance, Incontinence, and Swallowing

Author: Hammond, D. C.[1]
Source: Journal of Neurotherapy, Volume 9, Number 1, 8 July 2005 , pp. 27-36(10)
Publisher: Haworth Press
Abstract:
An innovative neurofeedback protocol for the treatment of problems with physical balance, incontinence, and swallowing is described. Successful case reports from four consecutively treated cases are presented. This protocol holds potential promise for work with the elderly, stroke and head injury patients, primary nocturnal enuresis, and in peak performance training where balance is important. Further controlled research is warranted.

**

The Boys Totem Town Neurofeedback Project A Pilot Study of EEG Biofeedback with Incarcerated Juvenile Felons

Authors: Martin, George[1]; Johnson, Cynthia L.[2]
Source: Journal of Neurotherapy, Volume 9, Number 3, 23 May 2006 , pp. 71-86(16)
Publisher: Haworth Press
Abstract:
Seven male adolescents, ages 14 to 17 who were in a juvenile detention residential treatment program and diagnosed with the combined type of Attention Deficit Hyperactivity Disorder (ADHD-C) or with Conduct Disorder, participated in a study examining the effects of electroencephalographic (EEG) neurofeedback on sustained attention, response inhibition, executive functions, intellectual ability, and memory. All of the participants received 20 sessions of EEG biofeedback therapy in conjunction with treatment received in a residential program. Pre- and post-treatment measures were collected within one week of treatment, and data were analyzed using an adapted model of Jacobson and Truax's method of clinically significant change (Jacobson & Truax, 1991) which allows criterion scores to be set and 95 percent confidence intervals determined at the level of individual performance on the collected measures. Sixty-four percent experienced improved performance after EEG neurofeedback on one or more measures. Clinically significant and reliable improvements were observed on teacher ratings of the Global Executive Composite from the Behavior Rating Inventory of Executive Function (average improvement = .22 mean item raw score points; Gioia, Isquith, Guy, & Kenworthy, 2000). Normal range performance was enhanced on the Composite IQ measure of the Kaufman Brief Intelligence Test (average gain = 9 points; Kaufman & Kaufman, 1990), on the Omissions subscale from the Conners' Continuous Performance Test (average decrease = 13 errors; Conners, 1994) and on the four subtest screening measures from the Wide Range Assessment of Memory and Learning (Sheslow & Adams, 1990), with average gains ranging from 2.0 to 3.67 scaled score points across the four subtests. The results are consistent with previous findings, and suggest that the methodology used for data analysis is a useful tool to assess individual levels of change, and indicate that EEG biofeedback may be a useful adjunct in the treatment of juvenile offenders.

**

EEG Spectral-Power and Coherence: LORETA Neurofeedback Training in the Anterior Cingulate Gyrus

Authors: Cannon, Rex[1]; Lubar, Joel[2]; Gerke, Aric[3]; Thornton, Keri[4]; Hutchens, Teresa A.[5]; McCammon, Victoria[4]
Source: Journal of Neurotherapy, Volume 10, Number 1, 12 December 2006 , pp. 5-31(27)

Publisher: Haworth Press
Abstract:
Introduction. This study examines the EEG spectral power and coherence changes that occur as a result of LORETA neurofeedback (LNFB) training, which is a recently developed spatial-specific neurofeedback protocol in which it has been demonstrated that human beings can learn to change activity in their own anterior cingulate gyrus. We trained individuals to increase low-beta (14-18 Hz) activity in the cognitive division of the anterior cingulate gyrus (ACcd). Methods. This study was conducted with eight non-clinical students with a mean age of 22. The participants completed over 30 sessions of LNFB training. We utilized the WAIS-III for pre- and post-psychometric measures to assess the influence of this training protocol. Results. We selected training Sessions 5, 10, 15, 20, 25, and 30 for comparison to Session 1. There are significant increases in absolute power and coherence over sessions. There is significant increase in the working memory and processing speed subtest scores. Discussion. The anterior regions of the cortex increase in the low-beta frequency relative to the ACcd at significant levels. The superior prefrontal cortex and occipital regions increase in the higher beta frequencies, but not in the trained frequency. The improvements in the working memory and processing speed scores suggest that LNFB had an overall positive effect in attentional processes, working memory, and processing speed.
doi:10.1300/J184v10n01_02

**

The LENS Neurofeedback with Animals

Authors: Larsen, Stephen[1]; Larsen, Robin[2]; Hammond, D. C.[3]; Sheppard, Stephen[4]; Ochs, Len[5]; Johnson, Sloan[6]; Adinaro, Carla[2]; Chapman, Carrie[2]
Source: Journal of Neurotherapy, Volume 10, Numbers 2-3, 27 December 2006 , pp. 89-104(16)
Publisher: Haworth Press
Abstract:
Background. A customary route for research in the life sciences is to begin with animal studies, and only after thorough evaluation, attempt the same procedure with humans. In this pilot clinical outcomes study, the inverse procedure is followed. Encouraging results in the areas of CNS regulation led clinicians to explore whether the method were equally effective with animals who suffered the same problems as humans. The qualities studied included aggressiveness, mood instability, hypervigilance, inability to learn from experience. Species studies over about three years consisted of horses, dogs, and cats. Method. All animals were treated on the Low Energy Neurofeedback System (LENS) using the I-330 C2, the mini-C2, or the GP plus EEG processor with a laptop computer. Unlike with human subjects, it was impossible to use Â"eyes-closedÂ" condition, so blink artifact was impossible to rule out. Animals stood in stalls, tied to hitching posts (horses), or on the floor or in their owner's lap (dogs and cats). With most animals the Â"stimÂ" condition was used, with a brief second or two of stimulation embedded in a longer period of Â"no-stim,Â" four to twenty seconds depending on the situation. Where possible, a cortical map was done of from ten to twelve sites on the animal version of the standardized mapping system developed by Holliday and Williams (1999, 2003) to match human mapping. Since it has become available several months ago, the Animal CNS Questionnaire was used, and a five symptom or more Â"Subjective Symptom ChecklistÂ" completed on each treatment session with the owner. Narrative reports were collected from owners, but also from professional animal trainers and handlers. In some cases animals were photographed or videotaped before and after. Results. The animal studies are similar in outcome to the human results. As judged by owners, independent witnesses and professional trainers and handlers, animal behavior improves in the dimensions of flexibility, calmness, emotional stability, intelligence and problem solving The authors did not feel placebo Â"controlsÂ" were necessary or appropriate to these experiments. They had head injuries, survived natural catastrophes, or were abused or neglected (sorry to say) by owners. What was observed, in case after case, is that the more treatments administered the Â"easierÂ" it became to administer additional treatments

(animals were more complaint and calm). Conclusion/Discussion. Results with animals are parallel to and confirmatory of results with human children and adults. Animals may be traumatized by many causes, not the least of which is human in origin. Thus it is rewarding to see a human procedure help them. With treatment, the animals seem more calm, adaptable, and natural. Some of the results resemble the easy and short-term treatments of human children and infants, who have not yet had a chance to acquire (more difficult to dislodge) habits and defense mechanisms around their problems. These studies are highly preliminary, but very encouraging. The authors would love to see the LENS method applied to a variety of species and in ever-increasing numbers. doi:10.1300/J184v10n02_08

**

The Neurophysiology of Dyslexia: A Selective Review with Implications for Neurofeedback Remediation and Results of Treatment in Twelve Consecutive Patients

Authors: Walker, Jonathan E.[1]; Norman, Charles A.[2]
Source: Journal of Neurotherapy, Volume 10, Number 1, 12 December 2006 , pp. 45-55(11)
Publisher: Haworth Press

Abstract:
Dyslexia is a common and important problem in all industrial societies, with a prevalence rate of five to ten percent, for which no consistently effective treatment is available. Recent advances in imaging (morphometric MRI, functional MRI, PET, regional cerebral blood flow), as well as in neurophysiology (evoked potentials, QEEG, event-related desynchronization, coherence studies, magnetic source imaging, reading difference topography) have clarified our understanding of the normal circuitry involved in reading and differences seen in individuals who have trouble learning to read. These studies have important implications for the use of neurofeedback to help dyslexic individuals learn to read more easily. First, we obtain a QEEG and a reading difference topograph. We then train down any abnormalities that are significantly increased and train up any abnormalities that are significantly decreased. Increasing 16-18 Hz activity at T3 (left mid-temporal area) has also proved quite helpful in improving reading speed and comprehension. These combined approaches have been helpful in all cases of dyslexia we have treated, dramatically so in some cases. Each of the 12 individuals treated improved by at least two grade levels after 30 to 35 sessions. doi:10.1300/J184v10n01_04

**

An MEG-based brain–computer interface (BCI)

Jürgen Mellinger[a], Gerwin Schalk[b, c], Christoph Braun[a], Hubert Preissl[a, f], Wolfgang Rosenstiel[d], Niels Birbaumer[a, e] and Andrea Kübler[a]

[a]Institute of Medical Psychology and Behavioral Neurobiology, MEG Center, University of Tübingen, Otfried-Müller-Str. 47, 72076 Tübingen, Germany

[b]Laboratory of Nervous System Disorders, New York State Department of Health, Albany, New York, USA

[c]Electrical, Computer, and Systems Engineering Department, Rensselaer Polytechnic

Institute, Troy, New York, USA
[d]Department of Computer Engineering, University of Tübingen, Tübingen, Germany
[e]Center for Cognitive Neuroscience, University of Trento, Trento, Italy
[f]Department of Obstetrics and Gynecology, University of Arkansas for Medical Sciences, Little Rock, Arkansas, USA
Received 17 September 2005; revised 20 February 2007; accepted 19 March 2007.
Available online 27 March 2007.

Abstract

Brain–computer interfaces (BCIs) allow for communicating intentions by mere brain activity, not involving muscles. Thus, BCIs may offer patients who have lost all voluntary muscle control the only possible way to communicate. Many recent studies have demonstrated that BCIs based on electroencephalography (EEG) can allow healthy and severely paralyzed individuals to communicate. While this approach is safe and inexpensive, communication is slow. Magnetoencephalography (MEG) provides signals with higher spatiotemporal resolution than EEG and could thus be used to explore whether these improved signal properties translate into increased BCI communication speed. In this study, we investigated the utility of an MEG-based BCI that uses voluntary amplitude modulation of sensorimotor μ and β rhythms. To increase the signal-to-noise ratio, we present a simple spatial filtering method that takes the geometric properties of signal propagation in MEG into account, and we present methods that can process artifacts specifically encountered in an MEG-based BCI. Exemplarily, six participants were successfully trained to communicate binary decisions by imagery of limb movements using a feedback paradigm. Participants achieved significant μ rhythm self control within 32 min of feedback training. For a subgroup of three participants, we localized the origin of the amplitude modulated signal to the motor cortex. Our results suggest that an MEG-based BCI is feasible and efficient in terms of user training.

NIR**

Functional Near Infrared Spectroscopy (fNIRS): An Emerging Neuroimaging Technology with Important Applications for the Study of Brain Disorders

Authors: Farzin Irani [a]; Steven M. Platek [a]; Scott Bunce [b]; Anthony C. Ruocco [a]; Douglas Chute [a]
Affiliations: [a] Department of Psychology, Drexel University, Philadelphia, PA [b] Department of Psychiatry, College of Medicine, Drexel University, Philadelphia, PA, USA
DOI: 10.1080/13854040600910018
Publication Frequency: 4 issues per year
Published in: The Clinical Neuropsychologist, Volume 21, Issue 1 January 2007 , pages 9 - 37
Subject: Neuropsychology;
Formats available: HTML (English) : PDF (English)

Abstract

Functional near-infrared spectroscopy (fNIRS) is an emerging functional neuroimaging technology offering a relatively non-invasive, safe, portable, and low-cost method of indirect and direct monitoring of brain activity. Most exciting is its potential to allow more ecologically valid investigations that can translate laboratory work into more realistic everyday settings and clinical environments. Our aim is to acquaint clinicians and researchers with the unique and beneficial characteristics of fNIRS by reviewing its relative merits and limitations vis-à-vis other brain-imaging technologies such as functional magnetic resonance imaging (fMRI). We review cross-validation work between fMRI and fNIRS, and discuss possible reservations about its deployment in clinical research and practice. Finally, because there is no comprehensive review of applications of fNIRS to brain disorders, we also review findings from the few studies utilizing fNIRS to investigate neurocognitive processes associated with neurological (Alzheimer's disease, Parkinson's disease, epilepsy, traumatic brain injury) and psychiatric disorders (schizophrenia, mood disorders, anxiety disorders).

**

Breaking the silence: Brain-computer interfaces (BCI) for communication and motor control

Author: Birbaumer, Niels
Source: Psychophysiology, Volume 43, Number 6, November 2006 , pp. 517-532(16)
Publisher: Blackwell Publishing
Abstract:
Brain-computer interfaces (BCI) allow control of computers or external devices with regulation of brain activity alone. Invasive BCIs, almost exclusively investigated in animal models using implanted electrodes in brain tissue, and noninvasive BCIs using electrophysiological recordings in humans are described. Clinical applications were reserved with few exceptions for the noninvasive approach: communication with the completely paralyzed and locked-in syndrome with slow cortical potentials, sensorimotor rhythm and P300, and restoration of movement and cortical reorganization in high spinal cord lesions and chronic stroke. It was demonstrated that noninvasive EEG-based BCIs allow brain-derived communication in

paralyzed and locked-in patients but not in completely locked-in patients. At present no firm conclusion about the clinical utility of BCI for the control of voluntary movement can be made. Invasive multielectrode BCIs in otherwise healthy animals allowed execution of reaching, grasping, and force variations based on spike patterns and extracellular field potentials. The newly developed fMRI-BCIs and NIRS-BCIs, like EEG BCIs, offer promise for the learned regulation of emotional disorders and also disorders of young children.