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**Emerging Brain-Based Interventions for Children and
Adolescents: Overview and Clinical Perspective** 1
Laurence M. Hirshberg, Sufen Chiu, and Jean A. Frazier

Electroencephalogram biofeedback (EBF), repetitive transcranial magnetic stimulation (rTMS), and vagal nerve stimulation (VNS) are emerging interventions that attempt to directly impact brain function through neurostimulation and neurofeedback mechanisms. This article provides a brief overview of each of these techniques, summarizes the relevant research findings, and examines the implications of this research for practice standards based on the guidelines for recommending evidence based treatments as developed by the American Academy of Child and Adolescent Psychiatry for attention deficit hyperactivity disorder (ADHD). EBF meets the "Clinical Guidelines" standard for ADHD, seizure disorders, anxiety, depression, and traumatic brain injury. VNS meets this same standard for treatment of refractory epilepsy and meets the lower "Options" standard for several other disorders. rTMS meets the standard for "Clinical Guidelines" for bipolar disorder, unipolar disorder, and schizophrenia. Several conditions are discussed regarding the use of evidence based thinking related to these emerging interventions and future directions.

**The Role of Quantitative Electroencephalography in Child and
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Robert J. Chabot, Flavia di Michele, and Leslie Prichep

This article presents a critical review of quantitative electroencephalographic (qEEG) research and issues relevant to its clinical

application. Included is a summary of methodologic issues necessary for a reliable implementation of qEEG within clinical settings and a brief discussion of controversial issues surrounding this implementation. The main body of the article includes a summary of qEEG findings that involves adults with various neurologic and psychiatric disorders, which is followed by an in-depth presentation of qEEG research that involves children and adolescents with neurologic and psychiatric disorders. A concluding section presents a qEEG-based neurophysiologic model of attention deficit disorder.

Electroencephalographic Biofeedback (Neurotherapy) as a Treatment for Attention Deficit Hyperactivity Disorder: Rationale and Empirical Foundation

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Vincent J. Monastra

During the past three decades, electroencephalographic (EEG) biofeedback has emerged as a nonpharmacologic treatment for attention-deficit/hyperactivity disorder (ADHD). This intervention was derived from operant conditioning studies that demonstrated capacity for neurophysiologic training in humans and other mammals and targets atypical patterns of cortical activation that have been identified consistently in neuroimaging and quantitative EEG studies of patients diagnosed with ADHD. This article presents the rationale for EEG biofeedback and examines the empirical support for this treatment using efficacy guidelines established by the Association for Applied Psychophysiology and Biofeedback and the International Society for Neuronal Regulation. Based on these guidelines, EEG biofeedback is considered to be “probably efficacious” for the treatment of ADHD and merits consideration as a treatment for patients who are stimulant “nonresponders.” Although research findings published to date indicate positive clinical response in approximately 75% of patients treated in controlled group studies, additional randomized, controlled trials are needed to provide a better estimate of the robustness of this treatment.

Critical Validation Studies of Neurofeedback

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John Gruzelier and Tobias Egner

The field of neurofeedback training has proceeded largely without validation. In this article the authors review studies directed at validating sensory motor rhythm, beta and alpha-theta protocols for improving attention, memory, and music performance in healthy participants. Importantly, benefits were demonstrable with cognitive and neurophysiologic measures that were predicted on the basis of regression models of learning to enhance sensory motor rhythm and beta activity. The first evidence of operant control over the alpha-theta ratio is provided, together with remarkable improvements in artistic aspects of music performance equivalent to two class grades in conservatory students. These are initial steps in providing a much needed scientific basis to neurofeedback.

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D. Corydon Hammond

A robust body of neurophysiologic research is reviewed on functional brain abnormalities associated with depression, anxiety, and obsessive-compulsive disorder. A review of more recent research finds that pharmacologic treatment may not be as effective as previously believed. A more recent neuroscience technology, electroencephalographic (EEG) biofeedback (neurofeedback), seems to hold promise as a methodology for retraining abnormal brain wave patterns. It has been associated with minimal side effects and is less invasive than other methods for addressing biologic brain disorders. Literature is reviewed on the use of neurofeedback with anxiety disorders, including posttraumatic stress disorder and obsessive-compulsive disorder, and with depression. Case examples are provided.

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David L. Trudeau

Neurofeedback treatment for addictions in adults is probably efficacious, and several reported approaches are described with their indications. Neurofeedback is promising as a treatment modality for adolescents, especially those with stimulant abuse and attention and conduct problems. It is attractive as a medication-free, neurophysiologic, and self-actualizing treatment for a substance-based, brain-impaired and self-defeating disorder. More research, beginning with case reporting, is needed to assess use and efficacy in adolescents.

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Kirtley E. Thornton and Dennis P. Carmody

The application of electroencephalogram (EEG) biofeedback with reading disability and traumatic brain injury (TBI) is relatively recent. There are many studies regarding the effectiveness (improving attention and IQ scores) of EEG biofeedback in patients with attention deficit hyperactivity disorder, who are known to have a high rate of comorbidity for learning disabilities. This suggests the possibility that EEG biofeedback specifically aimed at remediating reading disability and TBI would be effective. This article provides strong initial support for this idea and provides reason to believe that assessment and training under task conditions are likely to be fruitful. Given the significance of these problems and the absence of very effective alternatives for remediation of these conditions, efforts to complete the needed research seem warranted. Clinical use of this intervention seems to be warranted with informed consent.

Neurofeedback Treatment of Epilepsy

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Jonathan E. Walker and Gerald P. Kozlowski

With electroencephalographic (EEG) biofeedback (or neurofeedback), it is possible to train the brain to de-emphasize rhythms that lead to generation and propagation of seizure and emphasize rhythms that make seizures less likely to occur. With recent improvements in quantitative EEG measurement and improved neurofeedback protocols, it has become possible in clinical practice to eliminate seizures or reduce the amount of medication required to control them. In this article, the history of neurofeedback for epilepsy is presented followed by discussions of the relevant neurophysiology of epilepsy. A model of how neurofeedback might raise the seizure threshold is then presented. Clinical experience using a quantitative EEG guided approach is described, including a representative case study.

Vagus Nerve Stimulation: Current Use and Potential Applications in Child and Adolescent Psychiatry

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James M. Martinez, Lauren B. Marangell, and Lauren Hollrah

Chronic and recurrent major depressive episodes are associated with significant morbidity and mortality, and available treatments often are ineffective or only partially effective. This issue is of particular concern in children and adolescents, because major affective disorders often begin early in life and follow a chronic, progressive course. Because the current treatment armamentarium for depressive episodes in this age group is limited, the investigation for safe and effective treatment interventions is warranted. Vagus nerve stimulation therapy has proven safety, tolerability, and efficacy in the treatment of epilepsy, and early findings suggest safety and efficacy in the treatments of adults with chronic and recurrent treatment-resistant mood disorders. This intervention also holds promise as a potential treatment in children and adolescents, although research is currently lacking.

Electroconvulsive Therapy and Repetitive Transcranial Magnetic Stimulation in Children and Adolescents: A Review and Report of Two Cases of Epilepsia Partialis Continua

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Oscar G. Morales, Michael E. Henry, Mitchell S. Nobler, Eric M. Wassermann, and Sarah H. Lisanby

Brain stimulation for the treatment of psychiatric disorders has received increasing attention over the past decade. The introduction of experimental means to stimulate the brain noninvasively with magnetic fields not only has raised interest in these novel means of modulating brain activity but also has refocused attention on a mainstay in the treatment of severe major depression and other disorders (electroconvulsive therapy). This article reviews

the current state of knowledge concerning the use electroconvulsive therapy, repetitive transcranial magnetic stimulation, and magnetic seizure therapy in children and adolescents. Two cases of medically intractable epilepsy partialis continua are presented to add to the limited literature on the use of repetitive transcranial magnetic stimulation in children and adolescents and illustrate the concept of using functional neuroimaging results to target the application of a focal intervention in an attempt to dampen hyperactive regions of the cortex.

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