

# PEDIATRICS®

Advanced Search

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

[Home](#)

[My Pediatrics](#)

[Journal Information](#)

[Current Issue](#)

[Past Issues](#)

[Subscriptions & Services](#)

[Contact Us](#)

Published online October 23, 2006

PEDIATRICS Vol. 118 No. 5 November 2006, pp. e1530-e1540 (doi:10.1542/peds.2005-2478)

## ARTICLE

### Self-regulation of Slow Cortical Potentials: A New Treatment for Children With Attention-Deficit/Hyperactivity Disorder

Ute Strehl, PhD<sup>a</sup>, Ulrike Leins, PhD<sup>b</sup>,  
Gabriella Goth, MD<sup>a</sup>, Christoph Klingner, MD<sup>a</sup>,  
Thilo Hinterberger, PhD<sup>a</sup> and Niels Birbaumer, PhD<sup>a,c</sup>

<sup>a</sup> Institute of Medical Psychology and Behavioral Neurobiology

<sup>b</sup> University Hospital for Psychiatry and Psychotherapy, University of  
Tübingen, Tübingen, Germany

<sup>c</sup> Human Cortical Physiology, National Institutes of Health, National  
Institute of Neurological Disorders and Stroke, Bethesda, Maryland

**OBJECTIVE.** We investigated the effects of self-regulation of slow cortical potentials for children with attention-deficit/hyperactivity disorder. Slow cortical potentials are slow event-related direct-current shifts of the electroencephalogram. Slow cortical potential shifts in the electrical negative direction reflect the depolarization of large cortical cell assemblies, reducing their excitation threshold. This training aims at regulation of cortical excitation thresholds considered to be impaired in children with attention-deficit/hyperactivity disorder. Electroencephalographic data from the training and the 6-month follow-up are reported, as are changes in behavior and cognition.

**METHOD.** Twenty-three children with attention-deficit/hyperactivity

## *This Article*

- › [Full Text](#)
- › [Full Text \(PDF\)](#)
- › [P<sup>3</sup>Rs: Submit a response](#)
- › [Alert me when this article is cited](#)
- › [Alert me when P<sup>3</sup>Rs are posted](#)
- › [Alert me if a correction is posted](#)
- › [Citation Map](#)

## *Services*

- › [E-mail this article to a friend](#)
- › [Similar articles in this journal](#)
- › [Similar articles in PubMed](#)
- › [Alert me to new issues of the journal](#)
- › [Add to My File Cabinet](#)
- › [Download to citation manager](#)
- › [© Get Permissions](#)

## *Citing Articles*

- › [Citing Articles via HighWire](#)
- › [Citing Articles via CrossRef](#)
- › [Citing Articles via Google Scholar](#)

## *Google Scholar*

- › [Articles by Strehl, U.](#)
- › [Articles by Birbaumer, N.](#)
- › [Search for Related Content](#)

disorder aged between 8 and 13 years received 30 sessions of self-regulation training of slow cortical potentials in 3 phases of 10 sessions each. Increasing and decreasing slow cortical potentials at central brain regions was fed back visually and auditorily. Transfer trials without feedback were intermixed with feedback trials to allow generalization to everyday-life situations. In addition to the neurofeedback sessions, children exercised during the third training phase to apply the self-regulation strategy while doing their homework.

**RESULTS.** For the first time, electroencephalographic data during the course of slow cortical potential neurofeedback are reported. Measurement before and after the trials showed that children with attention-deficit/hyperactivity disorder learn to regulate negative slow cortical potentials. After training, significant improvement in behavior, attention, and IQ score was observed. The behavior ratings included *Diagnostic and Statistical Manual of Mental Disorders* criteria, number of problems, and social behavior at school and were conducted by parents and teachers. The cognitive variables were assessed with the Wechsler Intelligence Scale for Children and with a computerized test battery that measures several components of attention. All changes proved to be stable at 6 months' follow-up after the end of training. Clinical outcome was predicted by the ability to produce negative potential shifts in transfer sessions without feedback.

**CONCLUSIONS.** According to the guidelines of the efficacy of treatments, the evidence of the efficacy of slow cortical potential feedback found in this study reaches level 2: "possibly efficacious." In the absence of a control group, no causal relationship between observed improvements and the ability to regulate brain activity can be made. However, it could be shown for the first time that good performance in self-regulation predicts clinical outcome. "Good performance" was defined as the ability to produce negative potential shifts in trials without feedback, because it is known that the ability to self-regulate without feedback is impaired in children and adults with attention problems. Additional research should focus on the control of unspecific effects, medication, and subtypes to confirm the assumption that slow cortical potential feedback is a viable treatment option for attention-deficit/hyperactivity disorder. Regulation of slow cortical potentials may involve similar neurobiological pathways as medical treatment. It is suggested that regulation of frontocentral negative slow cortical potentials affects the cholinergic-dopaminergic balance and allows children to adapt to task requirements more flexibly.

---

**Key Words:** ADHD • biofeedback • neurobehavioral outcome • EEG • electroencephalogram

**Abbreviations:** ADHD—attention-deficit/hyperactivity disorder • ES—effect size • EEG—electroencephalogram/electroencephalographic • SCP—slow cortical potential • DSM-IV—*Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*

---

Accepted May 26, 2006.

## PubMed

### PubMed Citation

Articles by Strehl, U.

Articles by Birbaumer, N.

## Related Collections

Neurology & Psychiatry

**This article has been cited by other articles:**



JOURNAL WATCH **PSYCHIATRY**

► **HOME**

### **Neurofeedback for ADHD**

Journal Watch Psychiatry, January 8, 2007; 2007(108): 1 - 1.

[\[Full Text\]](#)

---



---

[Home](#) | [My Pediatrics](#) | [Journal Information](#) | [Current Issue](#) | [Past Issues](#) | [Subscriptions & Services](#) | [Contact Us](#)

[Click here for faster international access](#)

© 2006 American Academy of Pediatrics. All rights reserved.