Neurofeedback for Attention-Deficit/Hyperactivity Disorder: Meta-Analysis of Clinical and Neuropsychological Outcomes From Randomized Controlled Trials

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Abstract
Objective
We performed meta-analyses of randomized controlled trials to examine the effects of neurofeedback on attention-deficit/hyperactivity disorder (ADHD) symptoms and neuropsychological deficits in children/adolescents with ADHD.

Method
We searched Pubmed, Ovid, Web of Science, ERIC and CINAHL through August 30, 2015. Random-effects models were employed. Studies were evaluated with the Cochrane Risk of Bias (RoB) tool.

Results
We included 13 trials (520 participants with ADHD). Significant effects were found on ADHD symptoms rated by assessors most proximal to the treatment setting, i.e., the least blinded outcome measure (standardized mean difference [SMD]: ADHD total symptoms\(=0.35\), 95% CI\(=0.11\) - 0.59; inattention\(=0.36\), 95% CI\(=0.09\) - 0.63; hyperactivity/impulsivity\(=0.26\), 95% CI\(=0.08\) - 0.43). Effects were not significant when probably blinded ratings were the outcome or in trials with active/sham controls. Results were similar when only frequency band training trials, the most common neurofeedback approach, were analysed separately. Effects on laboratory measures of inhibition (SMD\(=0.30\), 95% CI\(= -0.10\) - 0.70) and attention (SMD\(=0.13\), 95% CI\(= -0.09\) - 0.36) were not significant. Only four studies directly assessed if learning occurred after neurofeedback training. The risk of bias was unclear for many RoB domains in most studies.

Conclusion
Evidence from well-controlled trials with probably blinded outcomes currently fails to support neurofeedback as an effective treatment for ADHD. Future efforts should focus on implementing standard neurofeedback protocols, ensuring learning, and optimizing clinically relevant transfer.