Disseminating Neurofeedback for the Treatment of Childhood ADHD:

The Importance of Neurocognitive Assessments

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Abstract

This study addresses the significance of utilizing behavioral and cognitive measures of ADHD symptoms to assess treatment outcomes following moderate neurofeedback in a clinic. We administered a cognitive task to 31 children in study 1 and a behavioral survey to 12 parents in study 2. We found a significant decrease in ADHD symptoms on both measures following neurofeedback. This multifaceted outcome assessment is crucial for establishing neurofeedback effectiveness in clinics for children with ADHD.

1. Introduction

Neurofeedback (NFB) is a non-invasive neurocognitive intervention that relies on the principles of operant conditioning to retrain brainwave patterns associated with concentration and relaxation. In 2012, NFB received "Level 1 Best Support" as an evidence-based treatment for childhood ADHD according to the American Academy of Pediatrics.

NFB has resulted in reductions in cognitive tasks measuring inattention and impulsivity (Fuchs, Birbaumer, Lutzenberger, Gruzelier, & Kaiser, 2003), as well as parent and teacher reports of attention and hyperactivity (Leins et al., 2007). Many studies have employed only behavioral measures and parent report of ADHD symptoms (e.g., Miesel, Servera, Garcia-Banda, Cardo, Moreno, 2013), which may be subject to expectancy effects. Meta-analytic findings revealed significantly lower treatment effects for NFB studies utilizing blinded assessments compared to studies that relied on behavioral assessments, such as parent report (Sonuga-Barke et al., 2013). Only a few studies have employed cognitive assessments of ADHD symptoms (Bakhshayesh, Hansch, Wyschkon, Rezai, Esser, 2011; Fuchs et al., 2003), despite the fact that these assessments are less subject to bias and essential in fully examining NFB treatment outcomes.

Another limitation in establishing the clinical effectiveness of NFB is the lack of outcome assessment studies in community practice settings. While work is emerging (Hillard, El-Baz, Sears, Tasman, & Sokhadaze, 2013), the majority of published research is randomized controlled trials (RCT's) utilizing 30+ sessions of NFB with stringent enrollment criteria. Therefore, RCT results may not generalize to diverse clinical

populations where 30+ NFB sessions is not plausible. A recent non-RCT examining NFB for childhood ADHD found significant improvements on behavioral parent ratings of ADHD symptoms and computerized attention tasks after only 12 NFB sessions (Hillard, et al., 2013). Given these positive results, additional multi-faceted outcome assessment research is warranted to confirm the effectiveness of NFB for childhood ADHD in clinical settings.

The current research examined behavioral and cognitive outcomes of NFB to treat ADHD delivered in a clinic setting. Children were assessed for ADHD according to the DSM-IV-TR and received only 12 sessions of clinic-based NFB; comorbid diagnoses and medication were permitted. In study 1, participants performed a cognitive measure of ADHD symptoms; the CPT. In study 2, parents received an additional measure of child ADHD symptoms, the Conner's Rating Scale-Parent Form (CRS-P). It was hypothesized that there would be a significant decrease in ADHD symptoms on both the cognitive and the behavioral measures of ADHD following NFB. Additionally, this effect will be greater for the behavioral measure of ADHD symptoms since parent report measures are often subject to expectancy effects (Sonuga-Barke et al., 2013).

2. Method

2.1. Study 1

2.1.1. Participants

Thirty-one children (*n* males = 27; *n* females = 4) ages 8-14 (*M* age = 11.13, *SD* = 1.98) were recruited to participate in an IRB approved (UNCW H1213-93) program evaluation research study that included NFB clinic services. Children and adolescents were referred from community sources including schools and healthcare providers.

Eligible participants were required to meet DSM-IV-TR criteria for ADHD and have an IQ over 70. Exclusion criteria included psychotic symptoms, active mania, active suicidal behaviors, other neurological disorders; other comorbidity and medication was permitted.

2.1.2 Interviews and Measures

Kiddie Structured Clinical Interview- Present & Lifetime Version (K-SADS-PL; Kaufman, Birmaher, Brent, Rao, & Ryan, 1996) is a semi-structured diagnostic clinical interview assessing childhood psychopathology according to DSM-IV-TR.

Conner's Continuous Performance Task (CPT 2; Conners 2002) is a cognitive assessment of ADHD symptoms in children eight and older. This 14-minute computerized task examined inattentiveness, impulsivity, sustained attention, and vigilance.

2.1.3 Procedures

The parent or guardian completed the initial eligibility assessment at the Neurofeedback Clinic. Trained research staff conducted clinical interviews with parents and children using the K-SADS-PL. Eligible children then were administered the CPT.

Participants were scheduled to receive 12 NFB sessions in a 3-4 week period through BrainPaint software, which utilized individualized protocols for each participant. NFB consisted of theta/beta training to increase beta (12-30 Hz) and decrease theta (6-8 Hz) as well as sensorimotor rhythm (SMR) training to increase SMR activity (13-15 Hz.) During NFB, participants received feedback within 25 milliseconds about target brainwaves via visual and auditory stimuli. Each session was one hour or less in duration. When NFB was complete, children were administered another CPT to assess ADHD symptoms.

2.2. Study 2

2.2.1. Participants

Twelve children (*n* males = 10, *n* females = 2), ages 8-14 (*M* age = 11.42, 1.98) from study one had parents that voluntarily completed a survey of child ADHD symptoms. These participants were recruited from the same sources and were required to meet the same eligibility criteria as study 1.

2.2.2. Interviews and Measures

Participants in study 2 received the same diagnostic clinical interview (K-SADS-PL), cognitive measure of ADHD symptoms (the CPT), and inclusion/exclusion criteria as in study 1. Additionally, parents of study 2 participants received a behavioral survey of child ADHD symptoms, the Conner's Rating Scale Parent.

Conner's Rating Scale Parent (CRS-P; Conners; 2001) is a widely used, standardized, 45-item parent report that assesses ADHD symptoms in children ages 6-18.

2.2.3 Procedures

Participants in study 2 completed the same procedures as study 1 with the addition of the CRS-P completed by the parent at the baseline and the post-test assessments.

2.3. Data Analysis

Statistical analyses were conducted using IBM SPSS, version 19. One-way repeated measures Analysis of Variance (ANOVA) was conducted for both studies to examine pre- to post-test differences on cognitive and behavioral measures of ADHD symptoms. For study 1, the CPT errors were calculated and standardized from combined

omission and commission subscales. For study 2, a standardized total CRS-P score was utilized. Effect size was calculated by from pre- to post-test difference scores.

3. Results

3.1. Study 1

Mean and standard deviations for the pre and post-test CPT appear in table 1. Participants made statistically significantly fewer errors on the CPT following NFB, F (1, 30) = 4.87, p = .035. There was a small effect size for the CPT (Cohen's d= 0.30).

3.2. Study 2

Mean and standard deviations for the pre and post-test CRS-P, appear in table 1. Parents reported statistically significantly less ADHD symptoms following NFB, F (1, 11) = 16.44, p = .002. There was a large effect size for the CRS-P (Cohen's d= 1.19).

4. Discussion

The results suggest that statistically significant~~ly~~ differences in cognitive and behavioral ADHD symptoms can be detected with only moderate exposure to NFB (12 sessions) in a clinic setting. There was a large effect size for the behavioral measure of ADHD symptoms (CRS-P) and a small effect size for the cognitive assessment (CPT), in keeping with expectancy effects of parental report (Sonuga-Barke et al., 2013). Previous RCT studies of NFB have relied solely on behavioral assessments with strict inclusion criteria (e.g., Meisel et al., 2013). This study takes a crucial step in addressing the significance of utilizing behavioral and cognitive outcomes of ADHD in clinic-based children's mental health services.

There are limitations of the current study. Although, cognitive assessment aids in reducing the expectancy effects of parental report (Sonuga-Barke et al., 2013), we cannot

be certain that differences are not due to other factors. However, reductions in ADHD symptoms found following NFB are not likely to be due to maturation because of the short 4-6 week timespan of treatment (Rebok et al., 1997). Additional RCT's utilizing moderate doses of NFB, multifaceted assessment, and long term follow up are also needed to account for possible lurking variables contributing differences. We are also conducting long term follow up of our clinic participants to determine if these reductions hold over time.

This study ~~is~~ provides further support for Hillard et al.'s (2013) finding of ADHD symptom reductions in moderate exposure to clinic delivered NFB. We found significant pre- to post-test differences after only 12 sessions of NFB as opposed to 30-40 sessions in most RCTs. This outcome assessment study demonstrates that just one month of NFB delivered in a typical clinical settings yields measurable reductions in childhood ADHD symptoms.

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Table 1

Descriptive statistics, F-Values, and Effect Sizes for Pre-Post Test Measures

	Pre-Test	Post-Test				
Measure	*M (SD)*	*M (SD)*	*N*	*F*	*p*	Effect Size (*d*)
CPT[a]	52.52 (10.49)	49.37 (8.63)	31	4.87	0.035	0.3
CRS-P[b]	42.08 (11.31)	28.67 (10.33)	12	16.44	0.002	1.19

[a]CPT= Conner's Continuous Performance Task
[b]CRS-P= Conner's Rating Scale- Parent