Curr Psychiatry Rep
DOI 10.1007/s11920-012-0301-z

Current Status of Neurofeedback for Attention-Deficit/Hyperactivity Disorder

Nicholas Lofthouse · L. Eugene Arnold · Elizabeth Hurt

Abstract As conventional treatments offer incomplete benefit for over 33 % of children with attention-deficit/hyperactivity disorder (ADHD) and many refuse to try them, additional treatments are needed. One of the most promising is neurofeedback (NF, EEG biofeedback), which trains the brain with real-time video/audio information about its electrical activity measured from scalp electrodes. Since 2010, data from 8 randomized controlled studies of NF have been published with overall mean effect sizes of: 0.40 (all measures), 0.42 (ADHD measures), 0.56 (inattention), and 0.54 (hyperactivity/ impulsivity). Unfortunately, the benefit reported from randomized studies has not been observed in the few small blinded studies conducted. Main study strengths include randomization, evidence-based diagnostic assessments, multi-domain treatment outcomes, use of some type of blinding, and sham control conditions. Main study limitations include lack of large samples, abnormal EEG participant selection, double-blinding, and testing of blind validity and sham inertness. Most recently, a collaborative NF research group has been planning a definitive double-blind well-controlled trial.

N. Lofthouse (✉) · L. E. Arnold
Department of Psychiatry, The Ohio State University,
1670 Upham Drive,
Columbus, OH 43210, USA
e-mail: Nicholas.Lofthouse@osumc.edu

L. E. Arnold
e-mail: L.Arnold@osumc.edu

E. Hurt
Nisonger Center, The Ohio State University,
291C McCampbell Hall, 1581 Dodd Drive,
Columbus, OH 43210, USA
e-mail: Elizabeth.Hurt@osumc.edu

Keywords Attention-deficit/hyperactivity disorder · ADHD · Neurofeedback · NF · Neurotherapy · EEG biofeedback · Review

Introduction

Conventional treatments (Txs) offer only incomplete symptom relief for over 33 % of children with attention-deficit/hyperactivity disorder (ADHD) [1], and an unknown percentage refuse or stop them, additional treatments are needed [2]. Recent reviews of complementary and alternative Txs for pediatric ADHD [3] have recognized neurofeedback (NF, also called neurotherapy or EEG biofeedback) as one of the most promising. NF uses operant conditioning to alter electroencephalographic (EEG] brain wave patterns, training the brain with real-time video/audio/tactile information about its electrical activity measured from scalp electrodes (for further details see [4••].

Until the first publication of a randomized control trial (RCT) in 1996 [5], the scientific literature on NF involved only case studies and open or nonrandomized trials. Lack of randomization is problematic: reported results may be caused by selection effects associated with the expectations of participants/parents choosing their preferred Tx group, regression to the mean, nonrandom participant experiences (ie, participant history), practice with assessment measures or maturation, or to the interaction of any of these factors [5].

Nonspecific Tx effects threaten the internal validity of NF research. These include participations'/experimenters'/trainers'/raters' (ie, parents, teachers, and clinicians) expectations regarding study outcome, provider qualities, experimenter/trainer attention to the patient, practice paying attention/sitting still/inhibiting responses, Tx structures and apparatus, participants' motivation for improvement and/or

Published online: 14 August 2012

therapeutic alliance [6]. In Tx outcome research, participants', experimenters', trainers' and raters' expectations can be controlled by blinding them to the Tx condition the participant has been randomly assigned. Other non-specific Tx effects can be controlled by using a "fake" or sham/placebo Tx or another Tx that is comparable with the target Tx except for the specific active Tx component (in NF's case this is feedback contingent on the person's EEG). Without blinding of participants/experimenters/raters and Tx control groups matched in duration, intensity, and apparatus, specific Tx effects cannot be distinguished from nonspecific effects.

There is a disagreement in the field whether NF should be evaluated as an unblindable psychological Tx using American Psychological Association (APA) guidelines or as a blindable treatment similar to evaluating new medications, via a double-blind placebo-controlled study. Some [7] have argued against using a sham NF condition on the basis of the ethical principles outlined in the Declaration of Helsinki [8]. However, others [4••, 9], have suggested ways to ethically use a sham-NF condition. Whether we can practically use a double-blind sham Tx in NF research involves 4 issues: (1) A sham-NF condition requires data demonstrating that it is truly inert and not causing specific EEG learning by accidently reinforcing the desired EEG power profile. (2) A double-blind sham-controlled RCT has to maintain the operant conditioning principles for the active-NF Tx for learning to take place. (3) There must be empirical evidence of valid blinding of participants, informants and experimenters. (4) The final practical issue is whether a sample can be recruited and retained through pre- and post-Tx assessments and 40 Txs in a study known to include blinded random assignment to sham.

Summary of NF Research Pre-2010

From 1996, when the first RCT of NF for ADHD was published [5], until 2009, 4 more RCTs [10, 11] (with a 2-year follow-up) [12, 13••, 14, 15], and 1 meta-analysis [16••] on this topic were published. Two studies used a waitlist control (WLC), 2 in a non-NF Tx control condition, and 1 compared 2 types of NF. Three studies used some type of single-blinding but none used a double-blind. Mean Cohen's *d* [17] effect sizes (ESs, where reported or means and standard deviations available for calculation, $n=3$) were medium-large: 0.69 (all measures), 0.74 (ADHD measures), 0.77 (hyperactivity/impulsivity measures) and 0.85 (inattention measures). Although these studies boasted several strengths (eg, randomization, evidenced-based assessments (EBAs) to diagnose ADHD, DSM criteria, standard Tx outcome measures, multi-domain assessment, moderately sized samples, some type of blind in 3 cases, and NF-related neurophysiological changes) they also suffered from notable limitations (eg, lack of double-blinding, post-Tx FUs, tracking of adverse effects, and identification/monitoring of all concomitant and potentially confounding Txs). The meta-analysis [16••] of 15 studies (6 with randomization) reported ESs of $d=0.81$ for inattention, $d=0.69$ for impulsivity and $d=0.40$ for hyperactivity and concluded "Neurofeedback treatment for ADHD can be considered 'Efficacious and Specific' (Level 5) (p. 180)." However, due to their use of non-randomized studies and the absence of studies with blinding and sham-NF designs, we disagree with this conclusion noting that NF had not been shown superior to credible placebo or to established treatments [4••].

Detailed Review of NF Research Since 2010

A January 2010–March 2012 PsycINFO/Medline title search of relevant keywords identified 12 publications on NF and ADHD. Five involved RCTs [18–22] and 7 were reviews [23–29]. Although not identified in these search results, an additional 2 RCTs were published [30, 31] and we have an in-press RCT [32] and in-press review of 14 RCTs published or presented at conferences from 1994 to September 2010 [4••]. A paper-commentary-reply series of papers based on Sherlin et al's (2010[a]) position paper on NF for ADHD [9, 25, 33] was also published. A detailed discussion of the aforementioned 8 recent RCTs follows:

(1) Based on the first multisite RCT of NF for ADHD [13••, 14] involving 94 9 12-year-olds (80 % male), Gevensleben et al. [18] published a 6-month follow-up (FU) and (2) Wagner et al. [22] reported on NF-associated changes in slow-cortical potentials (SCPs). The initial study randomized medication- and psychotherapy-free participants to NF (1 block of theta/beta and 1 block of SCP training in a balanced order, at Cz (International 10/20 system of scalp electrode placement) or to computerized attention skills training. The design was semi-blind, as teachers were blind but children and trainers were not and 58 % and 63 %, of parents identified NF and control group assignment, respectively. Six-month FU data was reported on 65 % of participants who had not dropped-out or been excluded due to starting another Tx. At FU the NF group appeared to continue their pre-post Tx improvements over the control group on parent-rated DSM-IV ADHD total ($P<0.005$, $d=0.71$), inattentive ($P<0.05$, $d=0.73$), hyperactive/impulsive ($P<0.01$, $d=0.35$), and delinquent/aggressive scores ($P<0.01$, $d=0.52$); and Strengths and Difficulties Questionnaire hyperactive scores ($P<0.005$, $d=0.49$) and homework problems ($P<0.005$, $d=0.60$). As only 50 % of children were classified as responders (ie, 25 % reduction in parent-rated DSM-IV ADHD scores) and 19 % of the NF group started medication during FU, Gevensleben and colleagues concluded that NF is not effective for all

children with ADHD and recommended it as one component in multimodal Tx rather than as a stand-alone Tx. SCP NF was also found to be accompanied by an increase in the contingent negative variation (CNV), associated with cognitive preparation, and larger pre-Tx CNV was related to larger decreases in ADHD symptoms [22]. (3) In 2010, Perreau-Linck et al. [19] investigated 9 8- to 13-year-olds (89 % male) with ADHD-combined type (no comorbidity), rigorously diagnosed by evidence-based assessments (EBAs) and displaying an abnormal EEG pattern (increased anterior theta and decreased posterior beta based on Clarke et al's EEG-defined ADHD [34]). No participant took medication during NF Tx. Participants were randomized to an active NF (n=5), receiving 40 60-minute sessions of theta/sensorimotor rhythm (SMR, which is very low beta) NF, at C4, ×3/week for 7–9 weeks, or sham-NF (n=4) involving an author's prerecorded EEGs. Children, parents, and NF trainers were not told about group assignment but the examiner conducting pre- and post-Tx neuropsychological testing was not blinded. At post-Tx all parents, except 1 who missed debriefing, reported not knowing to which group their child was assigned. Both groups demonstrated significant (≥1.5 SDs) individual pre- and post-Tx improvements on several parent-rated Conners Rating Scale-Revised (CRS–R, [35]) subscales, particularly hyperactivity, with the sham group showing overall improvement. All participants improved on at least 1 of several neuropsychological tests, with more active-NF participants showing improvement on the Stroop Task Inhibition/Switching Condition [36] and more sham-NF participants demonstrating more improvement on the Stroop Task Inhibition Condition and CPT–II Variability measure [37]. The authors concluded, "the presence of placebo responses suggests that other factors, such as motivation or expectations, might contribute to the outcome of NF training in children with ADHD" (p. 230). ESs could not be calculated as mean and standard deviation (SD) were unavailable. (4) In 2010, Lansbergen et al. [20] reported on 14 8- to 15-year-olds from an ongoing study (93 % male), with DSM-IV:TR ADHD (with oppositional defiant disorder [ODD] and/or an anxiety disorder, rates not reported), diagnosed via an EBA and Quantitative EEG (QEEG) that deviated at least 1.5 SDs from a normative database. Over half (64.3 %) of the sample were on a constant dose of stimulants, and no participant was involved in psychotherapy during the study (involvement in school-based services was not reported). Participants were randomized to active-NF (n=8) or sham-NF (n=6). The former involved QEEG-guided individualized NF protocols, 88 % theta/SMR, at various sites, for 30 45-minute sessions, ×2/week over 20 weeks. The sham-NF group received feedback from a random EEG signal generated by the same technology. Children, parents, NF trainers, and assessment evaluators were not told about group assignment. All children attended all study visits and training sessions. At post-Tx, 75 % and 50 % of children/parents receiving active- and sham-NF, respectively, guessed they were receiving sham NF, which the authors interpreted as being at "chance level" (p. 7). Frequent monitoring throughout the study did not identify any significant adverse effects or sleep problems. Both groups had significant pre- post-Tx improvements of inattention (P<0.001, ES=0.16) and hyperactivity/impulsivity (P<0.001, ES=0.72) on the clinician-rated ADHD DSM-IV scale [38], but there were no significant differences between groups. Similarly, both groups improved (ES=0.45) on the Clinical Global Impressions-Improvement scale (CGI-I [39]). At 6-month FU, no significant differences between groups or across time were revealed on the ADHD DSM-IV scale. (5) In 2011, deBeus and Kaiser (book chapter [30]) reanalyzed data from a 2006 conference presentation [40] of a double-blinded, cross-over (active- to sham-NF) RCT on 53 7- to 11-year-olds (66 % males, 91 % Caucasian) diagnosed via EBAs with DSM-IV ADHD inattentive or (47 %), combined type (53 %) and comorbid ODD (34 %), and learning disorder (13 %). Over half (57 %) were on medication, discontinued 2 days before screening and during pre- and post-Tx assessment. In a randomly assigned order, participants received20 30-minute NF sessions of theta/beta/SMR at Fz, over 10 weeks, and 20 sham-NF sessions of equal intensity, duration, and frequency in the same setting for a total of 40 sessions. Sham-NF used random rewards from the same equipment to attempt to blind children, parents, and the NF technician, and to control for nonspecific Tx effects (teachers were also blinded). Another technician who checked and adjusted the feedback was not blinded but was separated from and did not have any contact with the participant or other NF technician. The reanalysis included only participants who completed all 40 Tx sessions of active- and sham-NF (42/53). These 42 participants were 7- to 11-year-olds (31 % males, 90 % Caucasian) with ADHD inattentive (43 %) or combined type (57 %) and comorbid ODD (40 %), anxiety spectrum disorders (33 %), and dysthymic disorder (17 %), 57 % of whom were on medication. After all 40 sessions, "NF learners" (NF-L, participants whose beta/theta+alpha [Engagement Index] improved 1 SD with active-NF, n=31) and "NF nonlearners" (NF-NL, n=11) were identified. The NF-L group had significantly better scores with active NF than with sham on the Conners Teacher Rating Scale-Revised (CTRS-R, [41]) ADHD Total (P<0.005, ES=0.50), Inattentive (P=0.01, ES=0.41), and Hyperactive-Impulsive (P=0.02, ES=0.37) Scales and on the Integrated Visual and Auditory Continuous Performance Test (IVA [42]) response control (P=0.003, ES=0.63) and attention (P=0.002, ES=0.60) tasks. The NF-L group also had a significant correlation during active-NF sessions but not during sham between the CTRS-R ADHD total and EI change scores (r^2=0.498, P=0.01 vs r^2=0.02). No Tx effects were found for the Conners Parent Rating Scale-Revised (CPRS-R, [43]). (6) In 2011, Steiner et al. [31] compared NF, attention training, and a WLC in a school setting. The sample included 41 sixth to

eighth graders (M age=12.4, 52.2 % male, 74 % Caucasian), with a physician diagnosis of ADHD. The majority were medicated (60 %). Participants were randomized to NF (n=13), AT of similar duration and frequency (n=13), or a 6-month WLC (n=15). NF was a theta/beta computer-based program at CZ, for 40- to 45-minute sessions, ×2/week over 20 weeks. AT involved a computer-based program of auditory and visual exercises designed to increase attention and reduce impulsivity. Tx fidelity was ensured via extensive training, Tx assistants completing Tx fidelity checklists and investigator's observation of Tx sessions. Compared with WLC, NF had significant improvements on the CPRS-R [33] cognitive Problems/Inattention (P<0.05, ES=0.8) and Hyperactivity (P<0.05, ES=0.7) subscales and the ADHD Index (P<0.05, ES=1.2); and the Behavior Assessment Scales for Children (BASC [44]) Attention Problems (P<0.05, ES=0.7) and Hyperactivity (P<0.05, ES=0.6) subscales. However, AT also had significant improvements, compared with WLC, on the CPRS-R Cognitive Problems/Inattention subscale (P<0.05, ES=0.8) and ADHD Index (P<0.05, ES=0.7); BASC Attention Problems subscale (P<0.05, ES=0.8); and Behavioral Rating Inventory of Executive Functioning (BRIEF) Global Executive Composite score (P<0.05, ES=0.6). No teacher-rated CTRS-R scales reached significance for either training group. Steiner and colleagues also noted that by the end of the study, 4/20 participants receiving intervention (NF or AT not specified) had stopped taking medication and another 2 reduced their dose. As all participants completed at least 19/40 sessions (M=23.4), understood Tx instructions, and parents were satisfied with the program, Steiner et al. concluded that both Txs were feasible for children with ADHD in a school setting. (7) In 2011, Bakhshayesh et al. [21] compared NF with EMG biofeedback (BF) for 35 6- to14-year-olds (74 % male, ethnicity not reported), diagnosed by EBA with ICD-10 hyperkinetic disorder (disturbance of activity and attention, 83 %) or attention deficit without hyperactivity (17 %), 26 % comorbidity and 14 % on stimulants. Participants were randomized to NF (n=18) or BF (n=17) using a single-blind design (assessment evaluator blind). NF involved fixed theta-beta thresholds, at CPz and FCz sites, for 30 sessions, 30 min/session, 2–×3/week, for 10–15 weeks. Using the same procedure, BF also used the same system but gave feedback on forehead muscle relaxation via frontalis musculature electrodes. All participants' parents also received 4 sessions of "psychoeducation, effective instructions, rewarding desired behavior, logical consequences" (p. 3). NF significantly reduced the theta-beta ratio in 2 of 3 computer-based games (P=0.011 and 0.022, ES=0.39 and 0.35) and BF reduced EMG amplitude in all 3 games (P=0.001, 0.001 and 0.020, ES=0.55, 0.52 and 0.35). Compared with BF, NF had significantly greater pre- post-Tx improvements on parent-rated inattention (P<0.05, ES dcorr=0.94), paper-pencil measures of selective/focused attention ([45, 46]: Speed: P=0.001, ES dcorr=0.88, Errors P=0.044, ES dcorr=0.68, Total Scores P=0.007, ES dcorr=0.99), and on the Continuous Performance Test (CPT [47]) reaction time (P=0.011, ES dcorr=0.79) and marginally significant improvements on teacher-rated impulsivity (P<0.07). Both NF and BF significantly improved parent-rated hyperactivity, impulsivity, and overall ADHD symptoms, teacher-rated inattention and hyperactivity, and CPT commission errors. (8) We [32] conducted a double-blind, sham-controlled, randomized feasibility pilot study of NF with 39 6- to 12-year-olds (79 % male, 87 % Caucasian) with EBA of ADHD (combined 67 %, inattentive 33 %). All participants discontinued stimulants for the study and all concomitant Tx were monitored. Participants were twice-randomized: in a 2:1 ratio to active-NF (n≥24) vs sham-NF (n≥12), and simultaneously in a 1:1 ratio to ×2 vs ×3/week Tx frequency (≥18 in each frequency, ~12 active and ~6 shams). NF was given via Cz placement to decrease theta/alpha and increase beta, including SMR, for 40 45-minute Tx sessions, given 2–×3/week, over 16–20 weeks. Participants, parents, teachers, and staff were all blinded to Tx assignment. Sham-NF was administered in an identical manner (equipment, duration, frequency, and videogame choices) except random feedback was given not contingent on participant's EEG. To examine palatability of Tx session frequency (2 vs 3/week), at the 24th session, participants and their parents were given the option to continue with or change their initial frequency assignment. Tx fidelity was monitored and confirmed by the equipments' supplier via on-site observation, review of videotaped sessions, and phone consultations. In less than 2 years, even though they had to give up medication for the study, 39 participants were randomized. The retention rate was 87 % for 40 Txs and 92 % for 20 Txs. Guesses about Tx assignment by parents and children were no better than chance (only 32 % of children and 24 % of parents guessed correctly). At Tx 24, twice as many chose to switch from ×2 to ×3/week (44 %) vs ×3 to ×2/week (22 %), participant and parent satisfaction were high for both randomly assigned frequencies and parent/teacher-rated symptom outcome at Tx 24 was at least as good for ×3 as for ×2/week. On parent-rated ADHD symptoms there was no additional improvement after Tx 24. These results suggest that recruitment, retention, and valid blinding were all feasible for a double-blind sham-controlled and randomized study with a 6-month FU and the most feasible, efficient, and palatable Tx frequency was 3/week. Safety data, collected every session, was unremarkable with no adverse effects attributable to NF and no differences between NF and placebo. Clinical and neuropsychological outcomes generally showed no apparent advantage of active vs sham NF. In fact, the latter showed nominally better results on many measures. Both Txs showed large

significant pre-post ESs (~1) by Tx 24 on parent-ratings of ADHD symptoms, especially inattention, but there was no advantage for active- over sham-NF. FU data at 6 months was collected but not reported because of the lack of active- vs sham NF results.

Summary of RCTs

Of the 8 recent studies, 4 used a sham-NF control condition and 4 used a control-Tx condition; 7 have included some type of blinding, and 4 double-blinding; and 3 a FU. Where ESs were available or could be calculated (5 studies) overall mean ESs were of medium size: 0.40 (all measures), 0.42 (ADHD measures), 0.56 (inattention), and 0.54 (hyperactivity/ impulsivity).

Research on NF for pediatric ADHD has progressed a great deal with 11 RCTs, 10 of which (90 %) were published since 2006. Adding the ES data from the 8 recent studies to the 5 previous ones results in mean ESs of 0.57 (all measures), 0.60 (ADHD measures), 0.72 (inattention), and 0.70 (hyperactivity/ impulsivity). Overall strengths of these 8 studies include use of randomization, EBAs of diagnoses, DSM diagnoses, control of concomitant medication, measurement of comorbidity, multi-domain assessment, standard Tx outcome measures, frequently some type of blind (typically single), and a sham or control Tx condition. Overall limitations include lack of large samples, abnormal EEG participant selection, FU, double-blinding (ie, participants, raters [parents, teachers, clinicians] and NF trainers), consistent testing of blind validity, testing of sham inertness, control over presence/change in psychotherapy, and special education concomitant Txs, reporting of adverse effects, standardized NF protocols, and controlling for use of other, potentially confounding, non-NF Tx strategies.

Conclusions

In terms of the research implication of this review, based on this review and identified methodological limitations, the primary and essential area for improving research involves peer-reviewed and published randomized, double-blind, sham-NF-controlled trials, with large samples and FU. Such research will also require testing the validity of the blinded rather than just assuming participants are blinded, testing the inertness of sham-NF rather than assuming it is not providing active feedback, selecting participants based on abnormal EEGs, the continuous monitoring of potential adverse events related to the NF and sham conditions, and the identification and monitoring of potentially confounding concomitant Txs. The examination of whether a sham-NF is practically possible is not only theoretically interesting but also will have practical scientific and clinical implications. Consider the possible scenarios from such a study, (1) if shown that it is not practically possible to use a sham-NF because a truly inert sham-NF condition cannot be developed and validly blinded, then it can be argued that NF can only be evaluated using the same unblinded standards as psychological Txs; (2) if active-NF demonstrates significant clinical benefit beyond sham-NF, whether or not the sham also shows unintended EEG training, it is evidence for a specific NF effect suitable for adoption as an efficacious Tx [48] for ADHD, and justification for administration by well-trained clinicians; (3) if the active- and sham-NF conditions display no clinical outcome differences, then if the sham did not inadvertently train the EEG, it leads to the conclusion that NF did not have significant specific clinical effects beyond nonspecific Tx effects. But if sham did show unintentional EEG training and produced clinical outcomes as good as active-NF, it suggests the possibility of developing a cheaper, less intense NF protocol with preprogrammed random reinforcement, implemented by less trained staff.

Applying the APA Tx efficacy guidelines [48] to our research review, we conclude that NF Tx for pediatric ADHD is currently only "probably efficacious" and in need of a large multi-site double-blind sham-controlled RCT.

Most recently, a group of NF experts and ADHD Tx outcome investigators collaborated to develop a collaborative large (n=180), multi-site, double-blind, sham-controlled RCT of NF for ADHD. The initial dichotomy of views commonly found in the NF and ADHD fields (ie, a passionate advocacy for NF vs skepticism), evolved into a high level of collegiality with a mutual primary goal to rigorously examine NF, via a design, acceptable to all, which tests whether there is a specific effect of NF for ADHD. In addition to this main goal, the study will also examine whether any specific benefit persists for 2 years after Tx, if there are moderating variables that effect Tx response (eg, high initial theta-beta ratio [TBR]), whether NF's benefit is mediated by the hypothesized EEG TBR power changes, if selection for high TBR selects a group (biomarker) that is uniformly responsive to Tx regardless of ADHD subtype, and an exploratory analysis, using low-resolution electromagnetic tomography (LORETTA), to see if the function of deeper brain structures are affected by NF. An exploratory analysis will identify the proportion of children who have excess eyes-open TBR. Even though high TBR has repeatedly been associated with ADHD, the precise details are unclear because of varying conditions and definitions across studies. The collaborative study intends to standardize screening conditions in a large (~300 to screen) sample of 7- to 10-year-olds with rigorously diagnosed ADHD. We are currently seeking funding for this proposed study.

Regarding clinical implications, although current data indicate cross-domain improvement is medium-to-large with persistence of benefit and accompanied by neurophysiological changes, there are some critical methodological limitations

questioning the specificity of NF. Because the required investment of time (40 sessions) and money would tax the resources of most families, these current methodological limitations persuade us not to recommend NF for youth with ADHD until there is better evidence of a specific effect.

Disclosure N Lofthouse: none; LE Arnold: advisory board for Biomarin (one time), Noven, Seaside Therapeutics (one time), AstraZeneca (one time), and Shire; payment for lectures, including service on speakers bureau, from Shire; travel/accommodations/meeting expenses reimbursed from Shire; and grants from Shire, CureMark, and Lilly; E. Hurt: none.

References

Papers of particular interest, published recently, have been highlighted as:
•• Of major importance

1. Swanson JM, Kraemer HC, Hinshaw SP, Arnold LE, Conners CK, Abikoff HB, et al. Clinical relevance of the primary findings of the MTA: success rates based on severity of ADHD & ODD symptoms at the end of treatment. J Am Acad Child Adolesc Psychiatry. 2001;40:168–79.
2. Molina BSG, Hinshaw SP, Swanson JM, Arnold LE, Vitiello B, Jensen PS, et al. The MTA Cooperative Group. The MTA at 8 years: prospective follow-up of children treated for combined type ADHD in a multisite study. J Am Acad Child Adolesc Psychiatry. 2009;48:484–500.
3. Hurt EA, Lofthouse N, Arnold LE. Non-ingestible alternative & complementary treatments for attention-deficit/hyperactivity disorder. In: Hoza B, Evans SW, editors. Treating attention deficit hyperactivity disorder: assessment and intervention in developmental context. Kingston, NJ: Civic Research Institute; 2011.
4. •• Lofthouse N, Arnold LE, Hersch S, Hurt E, deBeus RJ. A review of neurofeedback treatment for pediatric ADHD. J Atten Disord. 2011;16(5):351–372. *Most comprehensive review of NF for pediatric ADHD*.
5. Linden M, Habib T, Radojevic V. A controlled study of effects of EEG biofeedback on cognitive and behavior of children with attention deficit hyperactivity disorder and learning disabilities. Biofeedback Self Regul. 1996;21:35–49.
6. Donovan HS, Kwekkeboom KL, Rosenzweig MQ, Ward SE. Nonspecific effects in psychoeducational intervention research. West J Nurs Res. 2009;31:983–98.
7. La Vaque TJ, Rossiter T. The ethical use of placebo controls in clinical research: the declaration of helsinki. Appl Psychophys Biof. 2001;26:25–39.
8. World Medical Association. The Declaration of Helsinki 52nd WMA General Assembly. Edinburgh, Scotland. 2000; author available at http://www.wma.net/en/30publications/10policies/b3/. Accessed 06 Aug 2012.
9. Lofthouse N, Arnold LE, Hurt E. A comment on Sherlin, Arns, Lubar, and Sokhadze. J Neurother. 2010;14:301–6.
10. Levesque J, Beauregard M, Mensour B. Effect of neurofeedback training on the neural substrates of selective attention in children with attention-deficit/hyperactivity disorder: a functional magnetic resonance imaging study. Neurosci Lett. 2006;394:216–21.
11. Leins U, Goth G, Hinterberger T, Klinger C, Rumpf N, Strehl U. Neurofeedback for children with ADHD: a comparison of SCP and theta/beta protocols. Appl Psychophys Biof. 2007;32:73–88.
12. Gani C, Birbaumer N, Strehl U. Long term effects after feedback of slow cortical potentials and of theta-beta-amplitudes in children with attention deficit-hyperactivity disorder (ADHD). IJBEM. 2008;10:209–32.
13. •• Gevensleben H, Holl B, Albrecht B, Vogel C, Schlamp D, Kratz O, et al. Is neurofeedback an efficacious treatment for ADHD? A randomized controlled clinical trial. J Child Psychiatry Psychol. 2009;50:780–9. *The most sophisticated, largest and only multi-site RCT of NF for pediatric ADHD*.
14. Gevensleben H, Holl B, Albrecht B, Schlamp D, Kratz O, Studer P, et al. Distinct EEG effects related to neurofeedback training in children with ADHD: a randomized controlled trial. Int J Psychophysiol. 2009;74:149–57.
15. Holtmann M, Grasmann D, Cionek-Szpak E, Hager V, Panzner N, Beyer A, et al. Spezifische wirksamkeit von neurofeedback auf die impulsivita¨ t bei ADHS. Kindheit Und Entwicklung. 2009;18:95–204.
16. •• Arns M, de Ridder S, Strehl U, Breteler M, Coenen A. Efficacy of neurofeedback treatment: the effects on inattention, impulsivity, and hyperactivity: a meta-analysis. Clin EEG Neurosci. 2009;40:180–9. *The first meta-analysis of NF for pediatric ADHD*.
17. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum; 1988.
18. Gevensleben H, Holl B, Albrecht B, Schlamp D, Kratz O, Studer P, et al. Neurofeedback training in children with ADHD: 6-month follow-up of a randomized controlled trial. Eur Child Adolesc Psychiatry. 2010;19:715–24.
19. Perreau-Linck E, Lessard N, Levesque J, Beauregard M. Effects of neurofeedback training on inhibitory capacities in ADHD children: a single-blind, randomized, placebo-controlled study. J Neurother. 2010;14:229–42.
20. Lansbergen MM, van Dongen-Boomsma M, Buitelaar JK, Slaats-Willemse D. ADHD & EEG-neurofeedback: a double-blind randomized placebo-controlled feasibility study. J Neural Transm. 2010;118:275–84.
21. Bakhshayesh AR, Hänsch S, Wyschkon A, Rezaj MJ, Esser G. Neurofeedback in ADHD: a single-blind randomized controlled trial. Eur Child Adolesc Psychiatry. 2011;20:481–91.
22. Wangler S, Gevensleben H, Albrecht B, Studer P, Rothenberger A, Moll GH, et al. Neurofeedback in children with ADHD: specific event-related potential findings of a randomized controlled trial. Clin Neurophysiol. 2011;122:942–50.
23. Little KD, Lubar JF, Cannon R. Neurofeedback: research-based treatment for ADHD. Handbook of integrative clinical psychology, psychiatry, and behavioral medicine: perspectives, practices, and research. New York, NY: Springer Publishing Co; 2010. p. 807–21.
24. Ramsay JR. Neurofeedback and neurocognitive training. Nonmedication treatments for adult ADHD: evaluating impact on daily functioning and well-being. Washington, DC: American Psychological Association; 2010. p. 109–29.
25. Sherlin L, Arns M, Lubar J, Sokhadze E. A position paper on neurofeedback for the treatment of ADHD. J Neurother. 2010;14:66–78.
26. van As J, Hummelen JW, Buitelaar JK. Neurofeedback and attention deficit hyperactivity disorder: what is it and is it working? Tijdschrift Voor Psychiatrie. 2010;52:41–50.
27. Williams JM. Does neurofeedback help reduce attention-deficit hyperactivity disorder? J Neurother. 2010;14:261–79.
28. Drechsler R. Ist neurofeedbacktraining eine wirksame therapiemethode zur behandlung von ADHS? ein berblick ber aktuelle befunde. Zeitschrift Fr Neuropsychologie. 2011;22:131–46.
29. Lofthouse N, McBurnett K, Arnold LE, Hurt E. Biofeedback and neurofeedback treatment for ADHD. Psychiatric Ann. 2011;41:42–8.
30. deBeus RJ, Kaiser DA. Neurofeedback with children with attention deficit-hyperactivity disorder: a randomized double-blind

placebo-controlled study. In: Coben R, Evans J, editors. Neuromodulation and neurofeedback: techniques and applications. Amsterdam, Holland: Elsevier; 2011. p. 127–52.
31. Steiner NJ, Sheldrick RC, Gotthelf D, Perrin EC. Computer-based attention training in the schools for children with attention deficit/hyperactivity disorder: a preliminary trial. Clin Pediatr. 2011;50:615–22.
32. Arnold LE, Lofthouse N, Pan X, Hurt E. Neurofeedback for attention-deficit/hyperactivity disorder: double-blind sham-controlled randomized pilot feasibility trial. J Atten Disord.(in-press).
33. Sherlin L, Arns M, Lubar J, Sokhadze E. A reply to Lofthouse, Arnold, and Hurt. J Neurother. 2010;14:307–11.
34. Clarke AR, Barry RJ, McCarthy R, Selikowitz M. Electroencephalogram differences in 2 subtypes of attention-deficit/hyperactivity disorder. Psychophysiology. 2001;38:212–21.
35. Conners CK. Conners' Rating scales–revised. Toronto, Canada: Multi-Health Systems Inc; 2001.
36. Delis D, Kaplan E, Kramer J. Delis-Kalpan executive function system examiner's manual. San Antonio, TX: Harcourt Assessment, Inc; 2001.
37. Conners CK. CPT-II, continuous performance test II. Toronto, Canada: Multi-Health Systems Inc; 2002.
38. DuPaul GJ, Power TJ, Anastopoulos AD, Reid R. ADHD Rating Scale-IV. Checklists, norms and clinical interpretations. New York: Guilford Press; 1998.
39. Wigal SB, Biederman J, Swanson JM, Yang R, Greenhill LL. Efficacy and safety of modafinil film-coated tablets in children and adolescents with or without prior stimulant treatment for attention-deficit/hyperactivity disorder: pooled analysis of 3 randomized, double-blind, placebo-controlled studies. Prim Care Companion J Clin Psychiatry. 2006;8:352–60.
40. deBeus R. Progress in efficacy studies of EEG biofeedback or ADHD. Paper presented at the meeting of the American Psychiatric Association, Toronto, Canada. May, 2006.
41. Conners CK. Conners' Teacher Rating Scale-Revised (CTRS-R) Toronto. ON: Multi-Health Systems Inc; 2002.
42. Sandford JA, Turner A. Manual for the integrated visual and auditory continuous performance test. Richmond, VA: Braintrain; 1995.
43. Conners CK. Conners' Parent Rating Scale-Revised (CPRS-R). Toronto, ON: Multi-Health Systems Inc; 2002.
44. Reynolds C, Kamphaus R. Behavior assessment scale for children manual. Circle Pines, MN: American Guidance Service; 1992.
45. Esser G, Wyschkon A, Ballaschk K. BasisdiagnostikUmschriebener Entwicklungsstörungen im Grundschulalter. Hogrefe, Göttingen; 2008.
46. Brickenkamp R. Test d2, Aufmerksamkeits-Belastungs-Test, 9th edn. Hogrefe, Göttingen; 2002.
47. Van Leeuwen TH, Steinhausen HC, Overtoom CC, Pascual-Marqui RD, van't Klooster B, Rothenburger A, et al. The continuous performance test revisited with neuroelectric mapping: impaired orienting in children with attention deficits. Behav Brain Res. 1998;94:243–63.
48. Chambless DL, Baker MJ, Baucom DH, Beutler LE, Calhoun KS, Crits-Christoph P, et al. An update on empirically validated therapies, II. Clin Psychol. 1998;51:3–16.