A randomized controlled trial to examine the post-treatment efficacy of neurofeedback, behavior therapy, and pharmacology on ADHD measures

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This research study has been funded by Plan Nacional i+d+i (National Research, Development and Innovation Program) (PSI2008–06008-C02–01)

Abstract

Objective: To examine the efficacy of neurofeedback (NF), behavior therapy (BT) and pharmacology (PH) on ADHD. **Method**: 59 children with ADHD (*M* = 8.80 yrs., *SD* = 1.92) were randomly assigned to one of the three treatments in a pre-post assessment design. Mothers and teacher rated ADHD scales, and children were assessed using The Integrated Visual and Auditory Continuous Performance Test (IVA/CPT). **Results**: The three treatments were effective on IVA/CPT, but with different trends. BT and especially NF got improvement in response control and attention, and PH mainly in visual attention. On rating scales, BT improved all measures, and NF and PH had a minor but interesting influence. **Conclusions**: From a global point of view behavior therapy has the most extensive results, but PH has the greatest capacity to improve overall attention, and NF is able to improve both control response and inattention. Clinical implications are discussed.

Keywords: randomized controlled trial, neurofeedback, pharmacological treatment, behavior therapy, attention deficit/hyperactivity disorder (ADHD), IVA/CPT, rating scales.

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Attention deficit hyperactivity disorder (ADHD) is one of the most common neurodevelopmental disorders during childhood and adolescence, with a worldwide prevalence about 5%, that severely affects schooling, family and social life and is characterized by symptoms such as inattention, hyperactivity and impulsiveness (APA, 2013). Pharmacological treatment is the option that is usually recommended in these cases. However, stimulant medications are not always accepted by parents, children or doctors due to the possible adverse effects (Peterson, McDonagh, & Fu, 2008).

Empirical studies generally compared the efficacy of pharmacological treatment with other therapy options. So, Leung and Hung (2008) in their study indicated that the combination of methylphenidate and behavioral therapy was significantly more efficacious reducing the symptoms of ADHD than pharmacological treatment alone. These findings have been corroborated by Eiraldi, Mautone, & Power (2012).

The MTA found that symptoms normalized in 68% of children treated with both stimulant medications and behavioral interventions (Lofthouse, Arnold, Hersch, Hurt, & deBeus, 2012). Thus, a combined application of both is recommended, especially for school-age children with combined ADHD subtype (Murray et al*.,* 2008) and when the characteristic symptoms and impairment of the child's general functioning are severe (NICE, 2013) (National Institute for Health & Clinical Excellence, 2013).

Regarding non-pharmacological interventions in the treatment of ADHD, such as psychological treatments, Fabiano et al. (2009) and Willis, Weyandt, Lubiner, & Schubart (2011), showed that behavioral therapy (applied as parent training or classroom management) is viable and effective in ADHD treatment. Hodgson, Hutchinson and Denson (2012) replicated and expanded the Fabiano et al. (2009) meta-analysis, and compared the efficacy of seven non-pharmacological interventions that included, behavioral modification, neurofeedback, school programs and parent training, concluding that such treatments have considerable potential in the treatment of children with ADHD. More specifically, the meta-analysis of Coates, Taylor and Sayal (2015) suggests that parenting interventions for ADHD are effective.

The efficacy of neurofeedback as a viable option to treat ADHD in relation to pharmacological treatment has been researched in different studies, randomized controlled trials, and meta-analysis yielding promising results to date (Arns, Heinrich, & Sthehl, 2014; Arns, Ridder, Strehl, Breteler, &Coenen, 2009; Duric, Assmus, Gundersen, & Elgen, 2012; Leins et al., 2007; Lofthouse et al., 2012). In a randomized controlled trial, neurofeedback training was found to be superior to a computerized attention skills training (Gevensleben et al., 2009). Duric et al. (2012) in a controlled and randomized clinical trial found that neurofeedback treatment seemed to improve the core symptoms of ADHD, as assessed by parental reports. When neurofeedback was administered in conjunction with pharmacological treatment, medication dose originally prescribed has been observed to decrease (Lora & Moreno, 2011) and Meisel, Servera, Garcia-Banda, Cardo and Moreno (2014) showed that effects were maintained for six months following treatment. Moreno-Garcia, Delgado-Pardo, Camacho-Vara de Rey, Meneres-Sancho, and Servera-Barceló (2015) showed that neurofeedback, pharmacological treatment and behavioral therapy are effective and cause similar effects in a specific electroencephalographic measure (theta/beta ratio).

However, conclusions about the effectiveness of neurofeedback, especially compared with the best treatment (pharmacology and behavior therapy), are still controversial. For example, in their respective revisions, Pigott and Cannon (2014) concluded that neurofeedback is a useful treatment against stimulant medication and behavior therapy as first-line treatments, while Loo and Makeig (2012) only recognize that in recent years the number and quality of research reports in neurofeedback have grown considerably, but the studies reviewed by them do not yet support this treatment as a first-line, stand-alone modality. In a similar vein, the Society of Clinical Child and Adolescent Psychology considers that neurofeedback is at Level 3 as a "possibly efficacious treatment" of ADHD (Evans, Owens, & Bunford, 2014). Therefore, many more studies are needed to know if neurofeedback can level up.

One of the main methodological issues in comparing the effectiveness of these treatments could be the use of different measures of ADHD symptoms. Ratings scales for parents and teachers have been the most common procedure and often the only. However, it seems recommended to add at least some neuropsychological task. For example, the Integrated Visual and Auditory Continuous Performance Test (IVA/CPT) (Sandford & Turner, 2002) has been used to define attention and behavior problems by comparing children with a diagnosis of ADHD and children with no history of the disorder (Moreno, Pardo, & Roldán, 2015), and to evaluated the efficacy of neurofeedback ((Moreno, Pardo, Aires, & Meneres*,* 2013; Yan et al., 2008) .

This is the background for this study, which aims to compare the differential efficacy of neurofeedback, pharmacological intervention and behavior therapy in ADHD symptoms measured by rating scales and neuropsychological variables. The specific objectives are the following: *a)* Determine the efficacy of neurofeedback, behavior therapy and pharmacological treatment on ADHD symptomatology using computerized (IVA/CPT) assessment tools and rating scales administered to parents and teachers and *b)* Compare the effects of neurofeedback versus behavior therapy and pharmacological treatment in attentional and behavioral variables, from three independent sources of information: children with a diagnosis of ADHD, parents and teachers.

Method

Participants

In the screening phase, 146 children with ADHD were recruited from the pediatric primary care units of a Health District of Sevilla (Spain). Of all these children 35 declined to participate and 52 were excluded for not meeting the inclusion criteria (see Figure 1): *1)* being between 7 and 14 years old, *2)* presenting a score above the 90th percentile in the teacher ADHD Rating Scale-IV and above the 80th percentile in the parents' version, 3) patients being drug-naïve before the first consultation, *4*), not presenting evidence of psychiatric disability or mental retardation (Kauffman Brief Intelligence Test), *5*), not present comorbid disorders with ADHD (Child Behavior Checklist, CBCL) and *6*) patients with no history of medical illness, chronic medical illness or current medical illness that may contraindicate pharmacological treatment.

PLEASE INSERT FIGURE 1 ABOUT HERE

The remaining 59 children were randomized to one of the conditions of administered treatments. During treatment two children dropped out. Therefore, 57 children completed the study (19 in each of the three treatments). The Human Research Ethics Committee of the University of Sevilla approved previously this investigation, and informed consent was obtained in all cases. Table 1 shows the participants' descriptive data.

PLEASE INSERT TABLE 1 ABOUT HERE

Materials and Procedure

Integrated Visual and Auditory Continuous Performance Test (IVA/CPT) (Sandford & Turner, 2002). This tool evaluates attention and control of responses to auditory and visual stimuli. The results are presented in standardized coefficients with an average score of 100 and a typical deviation of 15. We analyzed three global scales related to response control (Full Scale Response Control, Auditory Response Control, and Visual Response Control), and three others related to attention (Full Scale Attention, Auditory Attention, and Visual

Attention). We also analyzed the primary care scales (both with auditory stimuli as visual) related with response control and attention. Response control: Prudence (comission errors), Consistency (ability to respond reliably based in reaction time), and Stamina (ability to sustain speed of response by comparing the mean reaction time of the first 200 versus the last 200 trials). Attention: Vigilance (omissions), Focus (Reaction Time Variability), and Speed (Hits Reaction Time).

ADHD-Rating Scales-IV (ADHD RS-IV) (DuPaul, Power Anastopoulos, and Reid, 1998). It consists of 18 items that comprises two subscales, inattention and hyperactivity-impulsivity, and a total score. Mothers and teachers completed this scale. The higher the score, the higher the problems related with ADHD.

Attention Deficit Disorders Evaluation Scale (ADDES) (McCarney and Arthaud, 2004). Parents were asked to complete this scale separately, in order to evaluate inattentive and hyperactive/impulsive symptoms in a more extensive way than with the ADHD RS-IV scale.

Procedure

This is a design of an open randomized controlled group with pre- and post - treatment phases. Participants were randomly assigned to three experimental conditions corresponding to administered treatments (neurofeedback, behavioral therapy and pharmacology), and were evaluated with the same instruments and under identical conditions before and after therapeutic intervention. Pre-treatment evaluation was done approximately one week before treatment began, and post-treatment evaluation was done when the intervention was complete in all cases, i.e. after 20 weeks of intervention. In no case other treatments were administered simultaneously.

Treatment groups

Neurofeedback training (NF). This treatment was conducted using Atlantis II 2x2 equipment from Brainmaster, with an impedance check (below 5 Kohms) which automatically controls artifacts (>120 microvolts). EEG was analyzed in two frequency bands (theta: 4-7 Hz, beta: 15-20 Hz). EEG recordings were obtained using the monopolar signal Cz for participants between the ages of 7-11 and for older participants, EEG recordings used monopolar signal FCz, based on the International 10-20 system with ear references. Following the guidelines for the recommended treatment program (Monastra et al., 2005) participants received 4 Theta/Beta training sessions per week for a total of 40 sessions, wherein each session consisted of six four-minute runs, and at the beginning of each session baseline values were determined (30 seconds). Each session began with a previous period (2-5 minutes) for the purpose of get familiar with the procedure. Later, periods of training and EEG feedback, with an initial duration of 120 seconds were developed, that increased according to the learning curves of each child. Participants were rewarded for 70% of the time below the threshold in Theta, and up to 20% of the time below the threshold in Beta.

Behavioral Therapy (BT). Participants assigned to the behavioral therapy group received an intervention consisted in parent training including 10 group sessions, teacher training including 5 training sessions, and individualized children treatment including 15 individualized sessions of cognitive therapy, each lasting 50 minutes. Parents participated in weekly 90-minute sessions based on the Parent Training Program (Barkley, 1997). Each 90-minute teachers group sessions focused on two aspects, training on behavior modification strategies in the classroom (3 sessions) and specific curricular adaptations for ADHD (2 sessions) (Eiraldi et al., 2012). Teachers and parents received advice on implementing and reinforcing the behavior strategies acquired at home and at school.

Pharmacological Treatment (PH). Participants assigned to pharmacological treatment group received the ADHD treatment prescribed by the pediatrician that conducted their follow-up during referred 20 weeks. Pharmacological intervention has been adjusted to a common action protocol which included analytical, physical and neurological examination, somatometry and initial assessment of intensity of ADHD symptoms prior to treatment, as well as periodical dosage revision and recorded side effects. All patients received methylphenidate in its different formulations (immediate, intermediate release or OROS).

Data Analysis

With regard to the first objective, which focuses on the therapeutic change of the different treatments separately in relation to the two evaluation periods (pre- and post-treatment), a comparison of means was done for related groups (Paired Samples T-Test) and in absence of the required assumptions, Wilcoxon *t* tests were applied. For the second objective, where the differential efficacy of the three therapeutic options was examined, an analysis of variance (single factor ANOVA) was done, and the subsequent post-hoc contrasts were done between the treatments, with the Bonferroni correction to control the alpha error. In absence of the required model assumptions, Welch test or non-parametric Kruskal Wallis were applied.

As a measure of the efficacy of each treatment, the difference between the pre and post-treatment means (the "change" variable) was used, and effect sizes (Cohen´s *d*) were calculated. Thus, the results presented arise from comparing and contrasting 3 treatments (NF, BT, and PH) x three sources of information (children, mothers and teachers) x three different instruments; IVA/CPT, ADHD RS-IV, and ADDES.

Results

Comparing pre and post-treatment assessments.

Tables 2 shows pre-post differences in IVA/CPT variables for each therapeutic condition separately.

PLEASE INSERT TABLE 2 ABOUT HERE

When analyzing the performance of children treated by NF in IVA/CPT, we found significant differences in 15 out of 18 measures. Improving was similar both with visual stimuli (all the measures) as auditory (all except three, with two of them with p = .05). Children significantly improved in all global measures (except for Auditory Attention, p = .05). Effect sizes were large in four visual measures (Visual Response Control, Focus Visual, Speed Visual, and Visual Attention), and one auditory measure (Auditory Attention). Most of the remaining effect sizes were medium. To sum up, NF was able to improve almost all the IVA/CPT measures with a larger average global effect size (d = 0.80), ranging from 0.47 to 1.03.

When analyzing the results of PH treatment in IVA/CPT, we found significant differences in 11 out of 18 measures with large or very large effect sizes**.** Children significantly improved in all Attention Global Scales, but only in one Response Control Global Scale (Auditory). Also, we found significant differences in auditory stimuli but not visual in four variables: Response Control, Prudence, Stamina, and Vigilance. Differences were found in both stimuli in Full Scale Attention, Focus and Speed. Therefore two results should be highlighted: first, improvements in response control were only significant in auditory stimuli. And, second, improvements in attention ability were more extensive (auditory and visual stimuli) and relevant. As shown Table 2, the average effect size for attention was very large (d = 1.42**),** while for response control was medium **(**d = 0.73).

When analyzing the results of BT treatment in IVA/CPT, we also found significant differences in 11 out of 18 measures. The improvements in Global Scales were in Auditory Response Control and Auditory Attention, although it was also significant in Full Scale Attention (p = .047). It is remarkable that significant differences were found in all the primary scales with auditory stimuli (except for Focus, p = .054). On the other hand, this was the case only for three measures with visual stimuli. As shown Table 2, the average effect size of behavior therapy is *d* = 0.75 (medium), and it is slightly larger for attention variables (*d* = 0.77) than for behavior variables (*d* = 0.72).

Tables 3 shows pre-post differences in mother and teachers ADHD measures for each therapeutic condition separately.

PLEASE INSERT TABLE 3 ABOUT HERE

After NF treatment, significant differences were observed in 5 out 8 measures. Teachers showed improvements in hyperactivity, inattention and total score with large effect sizes. Instead, there were no significant differences in mothers ADHD RS-IV, and the significant differences found in ADDES showed a medium effect size for both hyperactivity and inattention subscales.

No significant differences were found in the mothers and teacher reports of children who have received PH treatment using the ADHD RS-IV scale. However, significant differences were observed in two mothers ADDES measures with medium effect sizes.

After BT treatment, there are significant differences in all the teachers and mothers measures. Large effect sizes were found in attention and total score teacher measures. The remaining measures showed an effect size equal or higher to 0.64.

Between treatments comparisons based in pre-post change variable.

For the second objective, the results of the inter-treatment comparisons based on ANOVA show that there have not been significant differences among the three treatments in parents and teachers rating scales. Instead, it has been found significant differences in 6 out 9 of variables measured by IVA/CPT (see table 4).

PLEASE INSERT TABLE 4 ABOUT HERE

The results reveal that treatments differ significantly only in the variables related to attention (no in response control), and these differences are quite favorable to PH intervention. Then, as seen in table 4, the post hoc analysis performed with Bonferroni, at confidence level of .05, indicates that PH treatment was superior to NF and BT in Full Scale Attention, Auditory Attention, and Visual Vigilance, and was superior to BT in Visual Attention. BT was superior to NF in Full Scale Attention and Auditory Attention, and was superior to PH only in Vigilance Auditory. NF was superior to PH in Visual Attention and Vigilance Auditory. Post hoc differences did not reach significance in Speed Auditory, but PH was superior to NF and BT with large effect sizes similar to those found in the aforementioned measures.

Discussion

The first objective of this study was to determine the differential efficacy of neurofeedback, pharmacology, and behavior therapy on ADHD neuropsychological measures and rating scales for parents and teachers. In relation to this objective we can conclude that separately the three treatments were able to generate changes and improvements in most of measures. Regarding neurofeedback and methylphenidate data are consistent with those obtained by Fuchs et al. (2003), and now we can add the positive data relating to behavior therapy. However, the scope of these improvements varies according to how efficacy is assessed (inattention or hyperactivity/impulsivity measured by IVA/CPT or rating scales) and the source of information consulted (mothers or teachers).

In terms of a child’s performance on IVA/CPT task, the three treatments may be considered relatively effective with similar effect sizes, but including some different trends. Thus, coinciding with Arns et al. (2009), neurofeedback improves response control (impulsivity) and attention, although the improvement is greater when the child responds to visual stimuli, as deBeus and Kaiser (2011) noted previously. Instead, the effect of pharmacological treatment can especially be seen in attention symptomatology regardless of the type of stimulation used. However, there is a differential effect in response control (i.e., hyperactivity/impulsivity behaviors) depending on the type of stimulation presented, with greater response inhibition when children are asked to respond to auditory stimuli. These results are consistent with findings from Fuchs et al. (2003) and Duric et al. (2012), although now the data comes from a randomized trial.

Regarding behavior therapy, findings are particularly relevant since it is not a treatment usually proposed for improving neuropsychological measures. The results show a therapeutic success similar for the response control and attention variables, but particularly with auditory stimuli. Effect sizes are slightly lower than those of pharmacology, and similar to neurofeedback.

The ADHD primary symptomatology assessed by parents and teachers scales was also significantly improved for the three treatments, although behavioral therapy was appreciably superior.

The effects of neurofeedback can mainly be seen in hyperactive/impulsive symptomatology. In comparison with previous studies, the effect size values for both hyperactive-impulsive as well as attention symptoms are closer to those found in Leins et al. (2007). When the source consulted are parents, results obtained are similar to Gevensleben et al. (2009), but differ from those found in other studies (Duric et al*.,* 2012). In comparison with Leins et al*.* (2007), neurofeedback yields better results when the information is provided by the teacher. The effects of pharmacological treatment have been relevant in mother's inattention measures and in ADDES hyperactivity subscale, but no improvement has been shown by teachers. Therefore, to some extent neurofeedback and pharmacology showed similar results, as in Duric et al (2012) study, but it should be highlighted the superiority of neurofeedback in teachers ADHD measures. Finally, behavior therapy showed a significant improvement in all rating scales, once again demonstrating its effectiveness in such ADHD measures (Coates, Taylor and Sayal, 2015; Fabiano et al., 2009; Hodgson, Hutchinson and Denson, 2012); Willis et al. 2011).

The second objective of this study was to compare the improvement of post-treatment change among the three treatments. There were not any significant differences either rating scales, nor response control, but pharmacology was quite superior in attention ability measured by IVA/CPT: its improvement was larger than BT and/or NF in five variables (not influenced by the type stimulus presented). Neurofeedback and behavior therapy only were able to be superior in two and three measures, respectively.

The main implications of these findings are clinical: pharmacology, behavior therapy and neurofeedback ca be useful to improve ADHD primary symptomatology, but with differential effects. Data are quite consistent with previous studies and neurofeedback seems able to improve attention, hyperactivity and impulsivity measures, but especially with visual stimuli and with teachers in rating scales. Meanwhile, pharmacology is particularly powerful in improving attention ability and attention behaviors in mothers rating scales. But its effects are quite lower in response control and hyperactivity. By contrast the effect of behavior therapy is more widespread among all the measures used. As it might be expected, the intervention improves all inattention and hyperactivity rating scales measures. But perhaps more surprisingly, it also has positive effects on response control and attention abilities.

Therefore, from a global point of view we could consider that behavior therapy has the most desirable results (although it can be promptly surpassed on some measures by the other two treatments). According to Pfiffner et al. (2013), the strategies that are currently applied at school for ADHD are not based on scientific evidence, as they do not consider the cognitive limitations that these students suffer, being their application not systematic enough to consolidate therapeutic effects and despite evidence of the need for interventions that promote self-control. Results found in this study support the combined treatment of ADHD with systematic behavioral training for parents and teachers as the main axis, and, depending on the characteristics of each case, we have the power of pharmacology to improve overall inattention, and the neurofeedback capacity to also improve control response in cognitive tasks.

Moreover, from the results another implication can also be highlighted in educative practice. The findings of this study suggests that adults must provide aural instructions to guide the child's performance and behavior, because, as can be noted, aural stimulation improves a child's attention to the task and helps reduce errors of omission. In response control, only measures based on auditory stimuli have been improved by pharmacology. Therefore, more emphasis should be placed on the assessment and intervention of auditory stimuli in ADHD.

The main limitations of this study are: (1) samples are too small to rely on statistical significance, although the results based on effect sizes can compensate for relatively this fact; (2) a similar study should be done with different ADHD subtypes, since this variable can have a decisive influence; (3) greater control of comorbid symptoms of ADHD participants would also be highly desirable; and (4), follow-up studies are necessary to properly analyze the treatments effects.

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Table 1.

Demographic and clinical characteristics of the participants.

	NEUROFEEDBACK GROUP (*N* = 19)	BEHAVIORAL GROUP (*N* = 19)	PHARMACOLOGICAL GROUP (*N* = 19)
AGE (*M* ± *SD*)	9.21± 1.9	8.11± 1.3	9.21± 2.2
% SEX (boys/girls)	79/21	74/26	79/21
Clinical Presentation DSM V (*N*)			
Combined presentation	7 (36.84%)	5 (26.31%)	8 (42.10%)
Inattentive presentation	8 (42.10%)	11 (57.89%)	8 (42.10%)
Hyperactive-Impulsive presentation	4 (21.05%)	3 (15.78%)	3 (15.78%)
IQ (K-BIT) (*M* ± *SD*)			
Crystallized (Verbal)	106.79±12.8	100.81±12	101.70±12.5
Fluid (Nonverbal)	101.93±11.8	97.94±17.7	93.3±10.8
IQ Composite	103.36±13	96.94±14.5	94.70±12.9

Table 2.

Pre-post comparison on IVA/CPT measures in each treatment

	Pre-treatment		Post-treatment			
Measures	*M*	*SD*	*M*	*SD*	*t*	*d*
NEUROFEEDBACK						
FS_RC	98.15	8.72	103.61	10.03	-2.50*	0.69
A_RC	101.57	11.88	108.35	11.65	-2.94*	0.78
V_RC	94.84	11.73	102.23	10.59	-3.73**	1.03
PR_A	103.85	11.21	108.14	8.34	-2.18*	0.58
PR_V	98.92	12.63	105.15	12.22	-2.81*	0.78
CON_A	97.28	13.23	101.28	15.56	-2.12	0.56
CON_V	93.23	13.33	101.53	11.40	-2.39*	0.66
STA_A	101.50	20.27	111.42	13.42	-2.95*	0.78
STA_V	98.38	13.49	104.84	16.49	-2.50*	0.69
FS_AT	92.30	13.37	95.92	15.21	-2.27*	0.63
A_AT	93.78	17.38	97.92	20.55	-2.15	0.57
V_AT	92.76	10.98	98.38	10.61	-2.91*	0.80
VIG_A	88.92	19.50	92.85	20.83	-1.77	0.47
VIG_V	92.12	12.54	97.30	14.12	-2.34*	0.63
FOC_A	92.00	11.85	101.14	14.55	-3.30**	0.88
FOC_V	92.76	9.24	99.07	6.33	-3.20**	0.89
SPE_A	107.78	15.04	111.35	13.81	-2.20*	0.58
SPE_V	99.46	12.73	102.38	12.56	-3.01	0.83
PHARMACOLOGY						
FS_RC	95.75	21.19	106.00	7.46	-1.78	0.63
A_RC	87.70	23.71	101.70	19.68	-2.47*	0.78
V_RC	100.12	16.03	107.37	6.86	-1.96	0.69
PR_A	90.30	22.56	105.50	15.50	-3.41**	1.07
PR_V	94.87	12.02	100.62	9.22	-1.67	0.59
CON_A	95,75	11.58	100.75	12.33	-1.93	0.68
CON_V	79.70	19.62	95.30	13.82	-3.13	0.99
STA_A	109.87	25.26	116.12	17.78	-1.88	0.66
STA_V	107.4	25.50	109	23.49	-0.44	0.14
FS_AT	74.87	22.85	99.87	19.35	-4.78**	1.69

A_AT	76.55	25.07	100.55	24.86	-4.96***	1.65
V_AT	80.50	17.18	102.12	13.89	-3.35*	1.18
VIG_A	59.90	35.70	92	27.75	-4.44**	1.40
VIG_V	84.20	18.56	95	15.32	-2.93*	0.92
FOC_A	92.12	15.31	103.5	9.94	-1.86	0.65
FOC_V	73.37	22.39	97.87	17.82	-3.20**	1.14
SPE_A	101.00	9.14	112.2	11.47	-2.78*	0.88
SPE_V	92.87	7.77	104.25	11.18	-2.43*	0.86
BEHAVIOR THERAPY						
FS_RC	97.40	16.62	102.00	13.78	-2.20	0.69
A_RC	89.40	15.76	100.46	15.92	-4.35***	0.95
V_RC	100.5	18.29	105.00	13.96	-1.58	0.49
PR_A	99.33	15.96	108.53	12.59	-2.59*	0.67
PR_V	101.80	17.24	109.40	10.33	-1.76	0.55
CON_A	82.06	16.36	92.26	16.24	-3.64**	0.94
CON_V	103.8	13.25	107.30	11.88	-2.48*	0.78
STA_A	96.80	15	105.20	17.07	-3.21**	0.83
STA_V	94.90	17.37	97.60	15.32	-1.71	0.54
FS_AT	84.40	15.98	92.30	16.30	-2.29*	0.72
A_AT	74.53	20.66	88.13	21.66	-3.46**	0.89
V_AT	92.60	11.94	99.30	10.70	-2.09	0.66
VIG_A	69.42	9.40	90.35	21.11	-2.69*	0.72
VIG_V	100.8	15.02	107.50	10.73	-2.57*	0.81
FOC_A	87.13	18.09	96.93	16.32	-3.26**	0.85
FOC_V	95.10	10.88	101.90	6.83	-1.79	0.56
SPE_A	100.66	14.50	103.60	12.65	-2.10	0.50
SPE_V	86.90	6.83	93.20	14.77	-2.69*	0.85

Note: FS_RC = Full Scale Response Control; A_RC = Auditory Response Control, V_RC =Visual Response control; PR_A =Prudence Auditory; PR_V = Prudence Visual; CON_A = Consistency Auditory; CON_V =Consistency Visual; STA_A = Stamina Auditory; STA_V = Stamina Visual; FS_AT = Full Scale Attention; A_AT = Auditory Attention; V_AT = Visual Attention; VIG_A = Vigilance Auditory; VIG_V = Vigilance Visual; FOC_A = Focus Auditory; FOC_V = Focus Visual; SPE_A = Speed Auditory; SPE_V = Speed Visual.

*$p \leq .05$; ** $p \leq .01$; ***$p \leq .001$. *d:* Cohen´s Effect Size.

Table 3.

Pre-post comparisons on ADHD rating scales in each treatment.

	Neurofeedback (*N* = 19)						Pharmacology (*N* = 19)						Behavior Therapy (*N* = 19)					
	Pre.		Post.				Pre.		Post.				Pre.		Post.			
	M	*SD*	*M*	*SD*	*t*	*d*	*M*	*SD*	*M*	*SD*	*t*	*d*	*M*	*SD*	*M*	*SD*	*t*	*d*
ADHD RS-IV Mothers																		
HI	17.43	4.98	14.21	6.77	2.08	0.59	12.40	8.69	8.80	5.82	1.25	0.42	15.38	6.66	9.94	5.42	3.43**	0.76
IN	17.64	4.63	15.86	6.81	1.01	0.34	19.30	5.41	14.40	3.83	2.11	0.85	19.75	5.07	14.31	6.41	3.46**	0.64
TS	35.07	8.18	30.07	13.05	1.62	0.43	31.70	13.30	23.20	9.64	1.72	0.55	35.13	11.08	24.25	1.22	3.75**	0.70
ADHD RS-IV Teachers																		
HI	17	9.09	10.86	8.35	3.15*	1.34	9.83	7.88	6.83	4.57	1.16	0.37	12.10	7.53	12.10	7.53	3.61**	0.74
IN	20.43	4.89	14.14	5.30	2.33	0.94	17.50	8.09	15.67	4.03	0.58	0.22	13.90	5.19	13.90	5.19	3.46**	1.54
TS	37.43	9.55	25	12.83	3.11*	1.21	27.33	14.80	22.50	7.06	0.95	0.31	26.00	11.90	26.00	11.90	3.88**	1.11
ADDES Mothers																		
HI	47.38	20.86	38.63	19.42	2.20*	0.58	33.55	22.22	21.00	20.01	2.44*	0.71	44.94	28.38	30.63	24.22	3.21**	0.79
IN	54.25	14.90	45.63	16.29	2.29*	0.61	50.91	14.43	38.09	21.61	2.49*	0.72	55.88	20.90	36.25	20.29	2.93***	0.73

Note: HI = Hyperactivity/Impulsivity, IN =Inattention, TS = Total Score.

Table 4.

Post hoc comparisons between treatments on IVA/CPT variables.

Change Variable	**Treatments**	**Mean Diff.**	***SE***	***p***	**95% CI**	***d***
Full Scale Attention	NF vs PH	-21.38	4,64	.001	9.56-33.20	2.09
	NF vs BT	-4.28	4,34	.998	-15.34-6.78	0.50
	PH vs BT	17.10	4.90	.005	4.62-29.57	1.47
Auditory Attention	NF vs PH	-19.85	5.40	.002	-33.44-.6.7	1.80
	NF vs BT	-9.45	4.69	.156	-21.27-2.35	0.76
	PH vs BT	10.40	5.33	.177	-3.00-23.80	0.75
Visual Attention	NF vs PH	15.63	5.22	.017	2.32-28.94	1.19
	NF vs BT	-1.08	4.89	1.00	-13.54-11.37	0.12
	PH vs BT	14,55	5,51	.041	0.49-28.60	1.03
Vigilance Auditory	NF vs PH	23.12	7.93	.019	3.13-43.11	1.00
	NF vs BT	-10.22	7.38	.525	-28.82-8.36	0.96
	PH vs BT	-33.35	8.06	.001	-53.66-13.04	1.07
Vigilance Visual	NF vs PH	-19.19	6.09	.011	-34.67-3.70	1.19
	NF vs BT	-0.78	5.55	1.00	-14.90-13.33	0.10
	PH vs BT	18.40	6.30	.020	2.39-34.42	1.07
Speed Auditory	NF vs PH	-7.62	3.33	.084	-16.00-.74	0.84
	NF vs BT	0.63	2.99	1.00	-687-8.15	0.18
	PH vs BT	8.26	3.28	.050	.009-16.52	0.97

Note: NF = Neurofeedback; PH = Pharmacology; BT = Behavior Therapy. *d* = Cohen's Effect Size.

Figure 1.

Distribution of the participants in the study.