Comparing the Effect of Neurofeedback and Verbal Self-Instruction on Children Afflicted with Attention-Deficit Hyperactivity Disorder: A Cognitive-Behavioral Approach

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Abstract

Attention deficit hyperactivity disorder is one of the developmental-behavioral disorders whose prevalence is between three to five years of age. There are several ways to cope with this problem. Two common methods for treating this disorder are verbal self-instruction and neurofeedback. This study intended to compare the effect of neurofeedback and verbal self-instruction on children afflicted with attention-deficit hyperactivity disorder using a cognitive-behavioral approach. To this end, 84 children afflicted with attention deficit hyperactivity disorder (ADHD) were selected. They were selected using purposeful sampling, and then they were randomly assigned to three groups of 28. The first two groups were selected as the experimental groups and the third group was selected as the control group. The children in the first group received verbal self-instruction for 16 sessions for sixteen weeks and the children in the second group received neurofeedback training for 32 sessions for sixteen weeks (twice a week). The third group, however, received no treatment whatsoever. Three instruments were used in this study, namely, Child Symptom Inventory-4 (CSI-4), Strengths and Difficulties Questionnaire (SDQ), and the Wechsler Intelligence Scale for Children (WISC-IV). Having analyzed the data, the researchers found that by controlling for the effect of pretest, there was a significant difference in the posttest scores of the groups. According to the post-hoc analysis, there was a significant decrease in the ADHD symptoms of the two experimental groups. However, the effectiveness of neurofeedback was higher than that of verbal self-instruction.

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Keywords: attention deficit hyperactivity disorder (ADHD), cognitive-behavioral approach, neurofeedback, verbal self-instruction

1. Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the common developmental-behavioral disorders whose prevalence is between three to five years of age (Ghasempour and Ramzani, 2015). ADHD is a stable pattern of lack of attention or hyperactivity or a combination of both which are more severe and more common in children with similar developmental level. This disorder should last for at least six months and should cause problems in an individual's social and academic performance (Angt et al., 2009). Children who are afflicted with ADHD have problems in their executive functioning. Executive functioning is a cognitive and meta-cognitive function which includes a set of abilities, inhibition, self-initiation, strategic planning, cognitive flexibility, and impulsive control. Executive functioning is also defined as a set of cognitive processes which guide other cognitive activities (Miller and Hinshaw, 2010). The most significant cognitive functions are concentration, planning, and working memory (Vosooghifard et al., 2013). Children with ADHD have many problems, especially regarding their education. Therefore, it is necessary to use effective methods in order to improve their concentration and their working memory. One of the recent methods is neurofeedback training (Wang and Hsieh, 2013).

Children with ADHD might not be able to pay attention to the details or might commit mistakes when doing their homework. If this disorder is not treated, the children and the teenagers will be at the risk of behavioral, educational, substance abuse, and mood disorders (Biederman, et al., 1996).

One of the new ways of treating ADHD is neurofeedback training. Treatment with neurofeedback was first introduced by Lubar (Simkin, Thacher and Lubar, 2014). This is a non-medicinal and self-regulatory approach which can increase self-control and self-regulation (Simkin, Thacher and Lubar, 2014). Neurofeedback is a safe and painless method in which sensors are connected to the patient's head. It is a link between psychology and physiology and is considered as a new approach to the explanation and treatment of mental and neurological diseases. It has even emerged as an approach to the promotion of mental capability and optimal performance.

Another approach to the treatment of ADHD is through using cognitive-behavioral approach (Daunic, et al., 2006). One of the models of this approach is verbal self-instruction developed by Meichenbaum (1975) and conceptualized by psychologists such as Luria (1979). Luria believed that children learn to control their behavior through the internalization of adults' orders (i.e. self-directed speech). In other words, this self-control is achieved through inner speech which occurs at several developmental stages. If these developmental stages do not occur in children, we should anticipate behaviors such as hyperactivity, impulsivity, and so on. In order to reduce these behaviors, we must repeat the normal growth sequence. In fact, verbal self-instruction is a kind of cognitive therapy in which the abnormal behavior of children suffering from hyperactivity disorder is assumed to be the result of a loss or defect in cognitive processes such as attention and inhibition. Thus, hyperactive children should be helped to think and plan before they act (Liebert and Spiegler, 1990). Studies on self-instruction therapy suggest its effectiveness in reducing the symptoms of this disorder (Hoza et. Al, 2005).

Although studies have shown the effectiveness of cognitive-behavioral therapies and neurofeedback in reducing the symptoms of this disorder, and even though some studies have compared the effectiveness of some cognitive behavioral therapies with neurofeedback (Tolpak et. Al, 2008), theoretical advances in cognitive-behavioral strategies and empirical evidence supporting the use of these therapeutic approaches have led to the prominent use of such treatments. In the cognitive-behavioral approach, it is assumed that children with ADHD have defects in cognitive and problem-solving strategies. Cognitive-behavioral therapists support behavioral interventions that lead to self-instruction (Arco, Cohen and Geddes, 2004).

One of the relatively new methods used in treating ADHD is neurofeedback treatment. Neurofeedback treatments have evolved on the basis of Mind-Body Relationship Theory and emphasize the ability of the mind to regenerate, modify and heal itself naturally. This method makes the treatment of ADHD disorders possible through brainwave effects and by increasing mental flexibility (Lubar, 1995). Neurofeedback is basically a kind of biofeedback which attempts to provide a kind of self-regulation to the patient by recording electrical waves and giving feedback. It is one of the methods of education and therapy, so that in a conditioning process one can learn to change the electrical activity of his or her brain. Individuals are typically provided with feedback through sounds or images, and they will know whether proper changes have been made in their brainwaves. In neurofeedback, sensors called electrodes are placed on the patient's scalp. These sensors record the electrical activity of the individual's brain and show it in the form of brain waves (often simulated in the form of computer games or videos). In this case, the video playback or the computer game is performed without the use of hands and is only done through brainwaves. In this way, individuals find out their favorable or unfavorable brainwave conditions by observing their progress, by losing points, or through changes in the sound or the video playback 2000 times in a 40-minute session and attempts to modify the production of their brainwaves by directing the game or the video (Breteler et. Al, 2010; Zoefel, 2011).

In some studies, it has been claimed that neurofeedback can be effective in the treatment of attention deficit hyperactivity disorder. In a study, it was shown that neurofeedback could reduce the behavioral and cognitive symptoms of ADHD (Fauzan and Nazaruddin, 2012). Moreover, some studies indicated that neurofeedback could improve children's active attention, not their inactive attention which is related to working with the computer (Enriquez-Geppert, Huster, and Herrmann, 2013). The difference between the pre-test and post-test scores of a group receiving neurofeedback treatment indicated its impact on brain waves (the reduction of theta band and an increase in beta band) (Lévesque, Beauregard, and Mensour, 2006). In a study, it was revealed that neurofeedback had a significant impact on the reduction of ADHD symptoms (Arns et al., 2009). In another study, the efficacy and usefulness of this therapeutic-educational approach to the treatment of ADHD and its combined form were acknowledged (Monastra, 2005). Neurofeedback is currently considered as an experimental intervention in children and adolescents afflicted with ADHD. Some studies have revealed that neurofeedback has a good impact on the attention-skill training program, and the ADHD symptoms improved moderately.

One of the methods based on cognitive-behavioral therapies is verbal self-learning. This method refers to the process through which the person explicitly examines the inner speech explicitly and externally, then, when he learns what to do, he performs it internally. Using verbal self-guidance, he directs his behavior to solve the problem. During this process, he uses verbal reinforcement to continue problem-solving activities. Current efforts in the treatment of this disorder have focused more on the modification of neurodegenerative, biochemical and psychosocial correlates. However, treatments via neuro-biochemical manipulation have been have been highly criticized because children and adolescents undergo neurobiochemical development under the influence of a predetermined genetic organization, and the use of chemical drugs, on the one hand, disrupts its natural development by interfering in the natural process of the development of the neurological system, and on the other hand, it will be followed by cognitive-behavioral damage.

Due to the lack of sufficient experimental evidence to confirm the neurobiochemical causes of ADHD, the lack of long-lasting effect of drug therapy, and the side effects of central nervous system stimulants, over the past decade, a significant number of studies have been conducted on the cognitive psychological therapies for these children (e.g. Hughes, 1998; Kendall and Braswell, 1993). One of the consequences of ADHD is the disruption of the cognitive functioning of the child, in such a way that he is unable to demonstrate the behavior appropriate to the environment. Therefore, the use of appropriate interventions such as behavioral-cognitive approach is deemed necessary. Based on this approach, children can be trained to improve their cognitive behaviors and have some degree of self-control. This interventionist approach to educating children in dealing with educational and non-educational issues, including: increasing the load of schoolwork, improving reading literacy among students with behavioral disorders, and reducing destructive behavior in children, indicates that the ability to speak with oneself can improve the child's ability to control behavior. Considering the theoretical foundations and research evidence of the effectiveness of cognitive-behavioral therapies in reducing the symptoms of ADHD in children and emphasizing the fundamental role of verbal self-instruction in teaching children to increase their knowledge, conducting a study on the effectiveness of verbal self-instruction in reducing ADHD symptoms seems necessary. However, few studies have been conducted comparing the effect of verbal self-instruction with neurofeedback. Therefore, this study seeks to answer the following research question:

Research question: Which treatment method is more effective in reducing ADHD symptoms, verbal self-instruction or neurofeedback training?

2. Method

2.1. Design

The present study was a quasi-experimental study with a pretest-posttest design involving a control group. The statistical population included children with ADHD who had referred to psychiatric and therapeutic centers in Shiraz.

2.2. Participants

The study sample included 84 children (68 males and 16 females) afflicted with ADHD who were selected from those who had referred to psychiatric and therapeutic centers in Shiraz. They were selected using purposeful sampling, and then they were randomly assigned to three groups of 28. The first two groups were selected as the experimental groups and the third group was selected as the control group. The children in the first group received verbal self-instruction for 16 sessions for sixteen weeks and the children in the second group received neurofeedback training for 32 sessions for sixteen weeks (twice a week). The third group, however, received no treatment whatsoever.

The inclusion criteria for the study included being diagnosed with ADHD by an expert in the field, having an IQ of 90 and above, and having a moderate socioeconomic status. The exclusion criteria of the study were concurrent impairments, brain damage, and neurological and sensory-motor problems.

2.3. Instruments

The following instruments were utilized in this study:

2.3.1. Strengths and Difficulties Questionnaire (SDQ)

This questionnaire assesses the strengths and difficulties of children in 25 statements. It has three response categories (not true, somewhat true, and certainly true). The first version of this questionnaire was developed by Goodman (1997). It has been translated into several languages including Persian. The questionnaire is a screening tool that is used to determine the emotional and behavioral problems of children and adolescents. The SDQ assesses both positive and negative behavioral aspects of children using five subscales: prosocial behavior, hyperactivity, emotional symptoms, conduct problems, and peer problems. It is an appropriate tool for assessing the problems of children and adolescents. The reliability of this questionnaire was calculated in Iran by Darvish Damavandi and Khorsandpour (2015).

2.3.2. Child Symptom Inventory (CSI-IV):

This questionnaire is a Behavioral Rating Scale developed by Gadow and Sprafkin (2002) for the screening of 18 behavioral and emotional disorders in children aged 5-12 years old. This scale has two versions, namely, the teacher version and the parent version. In this study, the teacher version has been used. It contains symptom categories for the following disorders: ADHD, Inattentive type (ADHD: I) which has 9 items, ADHD, Hyperactive-Impulsive type (ADHD: HI) which has 9 items, ADHD, and Combined type (ADHD: C) which has 18 items. Evidence shows the reliability of this instrument (Sprafkin et al., 2002). In Iran, Tavakkoli-zadeh et al. (1998) calculated the reliability of the teacher and parent versions of the CSI-IV as .90 and .93 respectively.

2.3.3. Wechsler Intelligence Scale for Children—Revised:

The fourth Wechsler Intelligence Scale for Children (WISC-IV) is a test of intellectual ability for children aged 6 to 16 years. It has 15 subtests. It was issued in 2003. The fourth edition of the WISC has been revised remarkably compared to the previous editions not only in terms of items but also regarding the concepts and the constructs. In the previous scales, three types of intelligence (verbal, practical and total) were calculated, while in the WISC-IV test, five types of intelligence are calculated which include: verbal comprehension, perceptual reasoning, active memory, processing speed, and total intelligence. Therefore, the number of subscales changed from 12 subscales to 15 subscales. There are five primary index scores, the Verbal Comprehension Index (VCI), Memory Index (WMI), Fluid Reasoning Index (FRI), Visual Spatial Index (VSI), Working and Processing Speed Index (PSI). The Verbal Comprehension scale subtests are described below:

- Similarities – (primary, FSIQ) which asks how two words are similar to each other.
- Vocabulary – (primary, FSIQ) which asks an examinee to define a provided word.
- Information (secondary) – which asks general knowledge questions.
- Comprehension – (secondary) which asks questions about social situations or common concepts.

The VSI is a measure of visual spatial processing.

The FRI is derived from the Matrix Reasoning and Figure Weights subtests. Its subsets are described below:

- Matrix Reasoning (primary, FSIQ) – in which children are shown an array of pictures with one missing square and they are required to select the picture that fits the array from five options.
- Figure Weights (primary, FSIQ) – in which children view a stimulus book which pictures shapes on a scale with one empty side and they are asked to select the choice that keeps the scale balanced.
- Picture Concepts (secondary) – in which children are provided with a number of pictures shown in two or three rows and they are asked to determine which pictures go together, one from each row.
- Arithmetic (secondary) – in which arithmetic questions are administered orally.

The FRI is a measure of inductive and quantitative reasoning.

The WMI is derived from the Digit Span and Picture Span subtests. Its subtests are as follows:

Digit Span (primary, FSIQ) – in which children are provided with a series of numbers orally and are asked to repeat them, as heard and in reverse order.

Picture Span (primary) – in which children view pictures in a stimulus book and select from options to indicate the pictures they saw, in order if possible.

Letter-Number Sequencing (secondary) – in which children are given a series of numbers and letters and asked to provide them to the examiner in a predetermined order.

The WMI is a measure of working memory ability.

The PSI is derived from the Coding and Symbol Search subtests. The Processing Speed subtests are as follows:

- Coding (primary, FSIQ) – in which children under the age of 8-mark rows of shapes with different lines according to a code, and children over the age of 8 transcribe a digit-symbol code. The task is time-limited with bonuses for speed.

- Symbol Search (primary) – in which children are given rows of symbols and target symbols, and they are required to mark whether or not the target symbols appear in each row.
- Cancellation (secondary) – in which children scan random and structured arrangements of pictures and mark specific target pictures within a limited amount of time.

The PSI is a measure of processing speed.

In Iran, Shahim (2006) investigated the reliability and the validity of the WISC-R on 1400 children aged 6 to 13. The test-retest reliability and the split-half reliability of the WISC-R were calculated as 0.44-0.94 and 0.42-0.98 respectively. The concurrent validity of the WISC-R for preschool children was calculated as 0.74. There was a statistically significant relationship between intelligence and age, socioeconomic status, and GPA. The correlation coefficients among verbal intelligence, practical intelligence, and total intelligence were 0.84, 0.76, and 0.80 respectively, and with the children's GPA were 0.52, .0.40, and 0.53 respectively.

Another study was conducted in Iran by Abedi, Sadeghi and Rabi (2007) in which the reliability of subtests was calculated through Cronbach's alpha and split-half methods. The validity of this instrument was reported as desirable. The results are provided in Table 1.

Table 1. The Reliability of Wechsler Intelligent Scale through Test-Retest and Split-Half Methods

Subtest	Test-Retest Reliability	Split-Half Reliability
Block Design	0.78	0.73
Similarities	0.75	0.76
Arithmetic	0.71	0.71
Visual Puzzles	0.65	0.74
Coding	0.84	0.84
Vocabulary	0.94	0.86
Letter-Number Sequencing	0.72	0.72
Visual Reasoning	0.85	0.86
Comprehension	0.78	0.81
Symbol Search	0.83	0.82
Picture Completion	0.85	0.84
Information	0.93	0.83
Calculation	0.80	0.74
Verbal Reasoning	0.83	0.81
Verbal Comprehension Index	0.88	0.91
Perceptual Reasoning Index	0.83	0.85
Working Memory Index	0.82	0.85
Processing Speed Index	0.80	0.83
Cancellation	0.77	0.77
Total Intelligence Quotient	0.91	0.95

2.4. Verbal Self-Instruction (VSI)

Doing verbal self-instruction involves whispering and private speech (Shapiro and Cole, 1994). The sequence of training requires the following steps:

Step one: Cognitive Modeling. It includes describing or modeling a task while the relevant steps are expressed aloud.

Step two: Overt external guidance. While the trainer provided the self-instruction training aloud, the children performed them, that is, the child responded in proportion with the training.

Step three: Overt self-guidance. While performing the tasks loudly, the children repeated the self-instruction techniques they were taught in the first and second steps; that is, the children displayed a behavior proportionate to the speech they produced.

Step four: Faded self-guidance: The children whispered the instructions while doing the task.
Step five: Covert self-guidance. The children performed the task guided by covert self-speech.

In each step, the skills that were taught to the children were as follows (Shapiro and Cole, 1994):

1. Problem Identification. "What is it I have to do?"
2. Focusing of Attention. "I have to concentrate, think only about my work."
3. Planning and Response Guidance. "Be careful . . . Look at one at a time."
4. Self-Reinforcement. "Good—I got it!"
5. Self-Evaluation. "Am I following my plan . . . Did I look at each one?"
6. Coping and Error-Correcting Option. "That's OK . . . even if I make an error I can back up and go slowly."

2.5. Neurofeedback Training

Neurofeedback has been described as an operant conditioning method through which individuals can self-regulate the electrical activities of their brain (Lévesque, Beauregard, and Mensour, 2006). As a matter of fact, neurofeedback refers to the operant conditioning of electroencephalographic rhythms. The activity of brain waves is proportional to age and health, either visual or auditory, and even stimulants of rewards and unpleasant activities are ignored or punished (Sterman, 1996). In this treatment, the information received by the two monitors was provided to the patient and the therapist and the patient and therapist were able to observe the brain waves of the patient, and by providing audiovisual stimuli, the therapist was able to manipulate abnormal waves and managed to turn them into normal during treatment sessions. During the neurofeedback training, the patient performed a video game on his monitor. In this therapeutic approach, some protocols have been developed. Regarding how to connect the electrodes on the patient's scalp, the electrodes were applied according to the International 10-20 System. This universal arrangement of electrodes makes it possible to cover almost all areas of the scalp by electrodes, and the location of electrodes can be selected based on the specific points of the skull bone. Electrodes are located in the intersection of the skull bone surfaces, and other intermediate electrodes are located based on 10% to 20% of the total distance (Hammond, 2011).
In this study, the treatment protocol was implemented in the FCz and C3 sites.

The participants were first administered a baseline at the Cz site. Then, the training sessions began. In the first stage, brain training at the FCz site was carried out to amplify the beta wave (18-21 Hz) and to suppress the theta brainwaves (4-7 Hz) and beta waves (22-30 Hz), and in the second stage, neurofeedback training was applied at the C3 site to amplify SMR wave (12-15Hz). This training process was repeated in two stages for a total of 32 sessions, and at the end of the training, a posttest was administered at the Cz site.

3. Results

The descriptive statistics of the ADHD scores in the pretest and post phases are shown in Table 2. Analysis of Covariance (ANCOVA) was used in order to compare the effectiveness of verbal self-instruction and neurofeedback training in the reduction of ADHD symptoms. The normality assumption, the homogeneity of regression slopes, and the homogeneity of error variance for each variable were tested. Table 3 indicates the covariance assumption of verbal self-instruction and neurofeedback training in the reduction of ADHD symptoms.

Table 2. Descriptive Statistics for ADHD Scores in the Pretest and Posttest Phases

	Verbal Self-Instruction		Neurofeedback Training		Control Group	
	SD	Mean	SD	Mean	SD	Mean
Pretest	1.97	11.64	1.21	11.41	1.83	11.76
Posttest	1.32	6.92	1.14	5.42	1.53	10.95

Table 3. The Covariance Assumption of Verbal Self-Instruction and Neurofeedback Training in the Reduction of ADHD Symptoms

	Assumption	Normality (Shapiro-Wilk)			Homogeneity of Regression Slopes		Equality of Variances (Levene's Test)	
Variable	Group	Phase	Statistic	Sig.	F	Sig.	F	Sig.
ADHD	Verbal Self-Instruction	Pretest	0.97	0.39	0.03	0.97	1.34	0.25
		Posttest	0.97	0.41				
	Neurofeedback	Pretest	0.98	0.53				
		Posttest	0.98	0.49				
	Control	Pretest	0.96	0.26				
		Posttest	0.98	0.68				

According to Table 3, the normality of data is confirmed based on Shapiro-Wilk's Test. Regarding the homogeneity of regression slopes, as Table 3 indicates, F is equal to 0.03 and it is not statistically significant at $P<0.5$). This indicates the homogeneity of the regression slopes in all groups. Regarding the equality of variances, as Table 3 indicates, the value of F is equal to 1.34. However, it is not statistically significant at $P<0.05$ level which indicates the homogeneity of variances.

In order to investigate whether there is a significant difference among the three groups, Analysis of Covariance (ANCOVA) was run. Table 4 shows the results.

Table 4. ANCOVA Results for the Effectiveness of Verbal Self-Instruction and Neurofeedback Training in ADHD Symptoms

Variable	Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
ADHD	Pretest	61.28	1	61.28	28.91	0.001	0.42
	Group	341.09	2	172.62	89.47	0.001	0.68

According to Table 4, by controlling for the effect of the pretest ($F = 28.91$, $P<0.05$) there was a significant difference among the three groups in the posttest ($F = 89.47$, $P<0.05$), and the eta squared value indicates that 68 percent of the changes in the posttest is due to the group membership, hence a statistically significant difference.

In order to determine the source of significance, multiple correlations were carried out. Table 5 provides the results.

Table 5. Results of Multiple Correlations of Treatment Groups in ADHD

Groups	Mean Difference	Standard Error	Sig.
Self-instruction-Neurofeedback	1.21	0.38	0.001
Control	-3.52	0.36	0.001
Neurofeedback-Control	-5.48	0.36	0.001

According to Table 5, there was a significant relationship among the three groups in the posttest scores of ADHD symptoms. The mean of the neurofeedback group is lower than that of the other two groups, and the mean of the self-instruction group is significantly lower than that of the control group. However, it is significantly higher than that of the neurofeedback group. In other words, neurofeedback training significantly decreased the ADHD symptoms compared to verbal self-instruction, even though self-instruction significantly reduced ADHD symptoms.

4. Discussion

This study aimed to compare the effect of neurofeedback and verbal self-instruction on children afflicted with attention-deficit hyperactivity disorder using a cognitive-behavioral approach. The results of the study indicated that both neurofeedback training and verbal self-instruction reduced ADHD symptoms. However, neurofeedback training had a stronger impact on the reduction of the ADHD symptoms. This finding is in line with that of Qaribi et al. (2017), and Pajares and Graham (1999).

The reduction of ADHD symptoms can be explained by the improvement in cognitive and non-physiological functions. According to Barkley's Executive Function Theory, the sign of disorder is the dysfunctional manifestation of executive functions including inhibition and self-talk (Barkley, 2014). These children have growth delay regarding their inhibition. Therefore, they do not have the verbal representation of environmental events. Moreover, since different parts of the frontal lobe inhibit various parts of the lateral cortex, damage to this area might cause certain symptoms. Therefore, attention-related problems are caused by the inability to inhibit the irrelevant stimulus information. Memory defects occur due to weaknesses in preventing previous memories, and problem-solving problems result from failure in blocking incorrect or inappropriate searching strategies. In fact, self-instruction training primarily affects these cognitive functions and makes them more efficient, and as a result, the symptoms ADHD diminish. In other words, verbal self-instruction training makes it possible for children with ADHD to control their emotions and achieve an excitation through their intrinsic motivation. On the other hand, these children can respond to stimuli and immediate events and increase their anticipated reactions to future events and might be directed toward goal-oriented behaviors (Moradi et al., 2011).

According to the theoretical underpinnings of this treatment, normal children develop cognitive processes through language. Since these developmental stages have not been passed in children with ADHD, during these treatment sessions, these children pass those stages appropriately and reach the stage of internal speech that is the stage of thinking. This educational method leads to the formation of verbal thinking through which the child can orient his or her behavior and to anticipate the future and maximize long-term implications. Accordingly, children who benefit from such training will be more successful in controlling their behavior and regulating their interpersonal relationships. Findings of the present study on the effectiveness of neurofeedback training are in line with those of Kaiser and Othmer (2000), Carmody et al. (2001), Monastra, Monastra and George (2002) and many other studies which indicated that neurofeedback training could reduce ADHD symptoms. The hypothesis underlying the use of neurofeedback training for ADHD is that if there is a neurobiologic dysfunction, especially at the cerebral cortex, and mainly in the frontal lobe, and if this dysfunction is treated, children with ADHD will be able to learn the strategies and patterns that ordinary children already know.

It can be concluded that increasing or decreasing the amplitude of theta and delta brain waves may have an effect on cognitive functions such as slowness of reaction time, impulse control, and decreased attention and excitement. The neurofeedback confirms the neurobiological basis of ADHD, so children, adolescents, and adults afflicted with ADHD have more theta brainwave activity and less beta brainwave activity, and the neurofeedback training helps them normalize the activity of these waves in response to the stimulants.

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