**Pharmacophore**

ISSN-2229-5402

Journal home page: http://www.pharmacophorejournal.com

Pharmacophore
an International Journal
ISSN 2229-5402

# THE EFFECTIVENESS OF NEUROFEEDBACK TRAINING ON BASELINE QUANTITATIVE ELECTROENCEPHALOGRAPHY (QEEG) AND SUSTAINED ATTENTION IN CHILDREN WITH ADHD

**Mohammad Mehdi Hassanshahi[1], Farideh Yousefi[2*]**

1. ***PhD student, School of Education and Psychology, Shiraz University, Iran***
2. ***Associate Professor of Educational Psychology, Shiraz University, Iran***

**ARTICLE INFO**

**Received:**
03th Jun 2017
**Accepted:**
29th Nov 2017
**Available online:**
14th Dec 2017

***Keywords:*** *Combined Type of Attention Deficit Disorder/ Hyperactivity, Qualitative EEG Baseline, Sustained Attention.*

**ABSTRACT**

This study was conducted to investigate the effects of neurofeedback training on qualitative EEG baseline and sustained attention in children with ADHD. Methods: This study was an experimental study conducted in the form of pre-test and post-test design with control group. The population of study consisted of all second to sixth grade elementary children who referred to Psychiatric Clinics in Shiraz city within the study time domain to receive treatment. The sample of the study consisted of 30 children diagnosed as attention deficit/hyperactivity disorder using the clinical psychiatric interview, determining EEG baseline, Snap V rating scale, and child behavioral checklist (parent form) by an independent therapist. The participants were matched in terms of educational levels, age, gender, and IQ scores and they were randomly assigned into experimental group (neurofeedback) and placebo group. Raven's Intelligence Test was conducted to balance the groups. The Continuous Performance Test was conducted on students of intervention group with neurofeedback and placebo group by a therapist. For the neurofeedback group, 30 training sessions were hold for 15 weeks and 2 sessions per week. The placebo group also participated in 30 sessions of the study and in each session, as neurofeedback training group, each subject was taken qualitative EEG. After recording baseline, neurofeedback device was turned off and children watched TV through monitor while electrodes were attached to them. EEG baseline and continuous performance test were conducted in 2-month time interval (follow-up test) after completion of the program on neurofeedback training intervention students and placebo students by an independent therapist. Results: the analysis of the results of research using multivariate analysis of covariance (MANCOVA) showed that neurofeedback training group showed significant progress in the qualitative EEG baseline and continuous performance test in comparison with the control group, and these progresses continued. In neurofeedback training group, theta wave activity and the ratio of theta/beta reduced in post-test scores and the activity of beta wave and sensory/motor rhythm increased significantly compared to pre-test score. In addition, reaction time, omission error, and commission error of children of training group in post-test and follow-up test were significantly lower in comparison to placebo group. Conclusion: neurofeedback training improved abnormal qualitative EEG and it was effective in improving the sustained attention of children with ADHD.



**To Cite This Article:** Mohammad Mehdi Hassanshahi, Farideh Yousefi, (2017), "The effectiveness of neurofeedback training on baseline quantitative electroencephalography (QEEG) and sustained attention in children with ADHD", ***Pharmacophore, 8(6S),*** *e-1173895.*

## Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder and it is one of the most common childhood disorders that its main characteristics is continuous pattern of attention deficit and / or hyperactivity-impulsivity that interferes with the function and development of the person. It is more severe and common compared to those who are at the same level of development [1]. This disorder is one of the most common psychological diagnoses in children [2]. According to the fifth Diagnostic and Statistical Manual of Mental Disorders of [1], investigations of different societies show that in most cultures, about five percent of children suffer from attention deficit / hyperactivity disorder. This disorder is more common in boys and its ratio compared to girls is 2:1. However, 3 to 7 percent of school-aged children suffer from this disorder [3]. According to the National Survey of Children's Health, over the years 2011-2012, one-tenth of school-aged children received

**Corresponding Author: Farideh Yousefi, Associate Professor of Educational Psychology, Shiraz University, Iran, Email: yousefi@shirazu.ac.ir**

a diagnosis of attention deficit/hyperactivity disorder. An increase of 42% was seen between the years 2003 and 2013 [4], which due to the high prevalence of impulsive behaviors of children with ADHD, these children are a challenge for teachers [5].

ADHD makes children vulnerable against failure in two important areas: school performance and peer relationships. These children may be disabled in learning in school-related functions, resulting from poor organizing, inattention, impulsivity, hyperactivity and distraction. Students with attention deficit / hyperactivity disorder who do not receive proper treatment will probably experience expulsion from school, low educational achievement, substance abuse, behavioral disorders and problems of social and emotional adjustment [6-10], so that, more than a quarter of children experiences failure in their studies and half of them renew their courses and 10 to 20% of them are expulsed from school. They obtain lower scores in intellectual tests and their academic achievement is lower considering their age [11].

Research carried out in various behavioral, genetic, neuro-psychological, and neurological areas and the studies conducted recently in the structural and functional imaging areas support the base of Neuropsychology, especially the role of the frontal lobe and prefrontal lobe, basal ganglia, and cerebellum in this disorder [12-21]. Hill and Beard (2006) [22] reported that the frontal cortex might be disrupted in children with attention deficit / hyperactivity disorder, which plays an important role in neurological high levels of executive functions such as working memory, inhibition, attention, organization and planning. Almost all the proposed models in attention deficit / hyperactivity consider this disorder as Executive neurological dysfunction or frontal cortex syndrome [15, 13-25].

Barkley (1997) [26] states that the main attention problem in children with attention deficit / hyperactivity is sustained attention. Sustained attention is one of the inhibitive behavioral functions and attention problem of children with this disorder is caused by the inhibitive behavioral interaction with executive functions. Based on the theoretical model of Barkley, response inhibition plays an important role in neurological executive functions and it is the ability to postpone response against environmental events. He believes that the main problem in attention deficit / hyperactivity is the deficit in response inhibition that is associated with four neurological executive functions that cause self-regulation. The four areas that fall in risk due to deficit in inhibition include working memory and perception of time, internalization of speech, regulation of emotion and reconstruction of new and complex behavioral chain [27].

In addition, researchers in neurophysiology area reported some disorders in the electronic imaging of the brain of people with ADH since 1930. Relying on these studies, they have tried to provide evidence on diagnosis, characterization, and treatment of attention deficit / hyperactivity. In the field of neurophysiology, the disorder is characterized by a deviant pattern of electro cortical activity, especially at rest along with an increase in theta and reduced activity of beta [28]. Studies conducted in this regard show the high activity of theta slow brain waves in the central and forehead areas. Increased activity of theta slow wave is often accompanied by low activity of beta fast waves. This suggests the low level of arousal, especially in the composite form of attention deficit/hyperactivity disorder [29,30]. Evidence shows decreased activity in regions of the frontal, central, and middle in approximately 85 to 90 percent of patients with attention deficit / hyperactivity disorder. Electroencephalography (EEG) indices obtained from quantitative EEG studies in patients with attention deficit/ hyperactivity disorder include: increased relative power of theta, reduced relative power of alpha and beta and increased relative theta power / alpha and theta / beta, seen mainly in middle, frontal, and central regions. According to these indices, biofeedback therapy and neural feedback were developed.

Neurofeedback logic is rooted in neurophysiologic studies that they have shown that there is relationship between EEG and underlying talamocortical mechanisms that are responsible for EEG rhythms and frequencies. According to Sterman (1996), nerve damage (such as attention deficit / hyperactivity) can alter these rhythms of neurofeedback training with the aim of normalizing these rhythms can lead to clinically stable effects. By neurofeedback training, participants learn and later their brain waves patent through the operant conditioning [31]. Neurofeedback research and executive function are conducted often on people with attention deficit / hyperactivity disorder [32]. Therefore, neurofeedback treatment for more than a decade has been investigated as a possible alternative treatment for children with attention deficit / hyperactivity disorder [33].

According to researchers in neurophysiology area, neurofeedback is a form of self-medication that improves the brain function through reorganization of the networks and brain chemical effects. Participants can regulate the activities of the brain waves with the help of special computer equipment by monitoring. The main hypothesis of neurofeedback is compatible with a model that believes attention deficit / hyperactivity disorder is caused by the low excitation of the brain. According to this model, the inadequate production and use of neurotransmitters cause failure of the transition among nerve cells. For this purpose, EEG sensors during a typical neurofeedback session are placed on the head skin of the participants, and obtained electrical records are immediately shown to participants as audio, visual, or audio-visual feedback [34]. Immediate feedback for participants is considered important to link special senses to EEG feedback sign. In other words, neurofeedback controls a person's brain wave activity status and trains the brain directly to produce special waves in specific areas of the brain and to change the direction of neuronal carriers before reaching to synapses, through changing neural network. In other words, when a neuron is altered through change in brain plasticity and this altered form of brain wave maintained its continuation, changes in mental and behavioral related to EEG occur [35]. At first, participants might be unable to recognize the cause of changes in feedback [36]. However, due to gradual practice and trial and error, most participants develop strategies to access different frequencies of brain waves over time, and self-control of brain waves can be trained and even it can be accessed without immediate feedback [36]. In neurofeedback, the special brain waves frequencies are enhanced or suppressed in order to produce the desired effect [37]. For example, theta wave (4 to 7 Hz) has been linked to active and beta memory (7 to 12 Hz) and to meaning long-term memory [38]. [39] reported that the number of neurofeedback sessions in experimental studies varies and typically it includes up to 35 sessions.

Most researchers consider 8 to 10 sessions successful. In the area of application of neurofeedback in the treatment of children with attention deficit/ hyperactivity disorder, most of the studies conducted in this regard have shown the positive impact of this method of therapy on the performance, sustained attention and behavior of individuals, although some studies are not in line with them. Lee (1991) [40] in a review study analyzed 36 studies in which the effects of neurofeedback treatment approaches in the treatment of attention deficit / hyperactivity disorder were examined. He argues that neurofeedback therapy alone is not effective in the treatment of attention deficit / hyperactivity disorder and studies conducted in this area have mainly methodological problems. He concludes that neurofeedback therapy in combination with other methods of treatment reduces some behavioral symptoms of attention deficit / hyperactivity disorder and improves it. [41] in a clinical study examined the effects of 40 sessions of neurofeedback combined with metacognitive strategies in the treatment of 111 patients with attention deficit / hyperactivity disorder. Neurofeedback sessions were twice a week in which each session lasted 50 minutes and metacognitive strategies were associated with academic tasks. The researchers concluded that treatment with neurofeedback combined with metacognitive strategies is an appropriate and beneficial method in the treatment of children with attention deficit / hyperactivity disorder. Carmody, Radvanski, Wadhwani, Sabo, & Vergara (2001)[42] examined the effectiveness of neurofeedback in an elementary school. The experimental group received 35 to 47 neurofeedback sessions. Based on the results, the sustained attention performance of subjects in the experimental group was improved significantly. The results of the study conducted by [43] on children with attention deficit / hyperactivity disorder showed that neurofeedback training to the children causes self-control and self-regulation of their behavior and this change leads to a reduction in impulsive behaviors and increased inhibition behaviors of their response.

Bakhshayesh, Schneider, Wyschkon, Esser, & Ihle (2007) [44] examined the impact of theta/beta neurofeedback in the treatment of children with attention deficit / hyperactivity. Based on the results obtained, a significant reduction was obtained in the neurofeedback group compared to theta / beta during therapy sessions. The results of the tests and parents and teachers questionnaires suggest that modifying the brain electrical waves' functions can reduce the symptoms of attention deficit/ hyperactivity disorder, while modifying the function of muscle waves did not lead to such result and results of variance analysis at the scale of continuous performance test showed significant differences. Steiner, Sheldrick, Gotthelf, & Perrin (2011) trained neurofeedback in school on 41 children with ADHD within four months and 2 45-minute sessions per week. The results showed that parents of children stated that the level of attention and hyperactivity reduced in their children, but teachers did not report improvement in symptoms of attention deficit / hyperactivity disorder. In line with this information, results of several studies with larger sample size have shown that children with attention deficit / hyperactivity disorder had abnormal quantitative electroencephalography.

On the other hand, according to [34], neurofeedback provides a mechanism to children with attention deficit / hyperactivity, who normalize their cortical profile through reducing slow wave activity and increasing the fast wave activity. It is expected that child to have more attention and focus through compensating electroencephalography abnormality, leading to improved academic performance. Accordingly, in [45], Lubar, & Shouse used operant conditioning to strengthen some of brain waves in the treatment of attention deficit / hyperactivity disorder. They used audiovisual feedback for neuron responses and they observed that we could reduce hyperactivity and improve attention with this method. Other researchers used this method for group-controlled studies. In one of these studies, [46] replaced 46 children with attention deficit / hyperactivity disorder in two groups of drug therapy and neurofeedback. During the three months, neurofeedback group received 20 sessions of neurofeedback training. The results showed that both groups had significant improvement and no significant difference was observed between the groups. In addition, this method is a treatment method with long-term effects for attention deficit disorder / hyperactivity [47, 48]. Several studies have shown that this training-medical method has been effective in increasing the attention and concentration and reducing hyperactivity and impulsivity and it causes self-control and behavior inhibition in people with attention deficit and hyperactivity [49].

Lusko et al. (2006) assigned 20 children aged 8-12 years with attention deficit / hyperactivity disorder into two neurofeedback training group (n= 15) and waiting list. Neurofeedback training group showed improvement in assignments of Digit Span, continuous performance scale, and parental behavior ranking. Snyder and Hall (2006) reviewed nine controlled studies (including 1498 subjects with ADHD) in comparison with normal control group and they announced the volume effect of neurofeedback treatment 80%, and they announced sensitivity of children behavioral ranking scales by comparing it with results of quantitative electroencephalography about 50% to 82%. Bink et al (2014) [32] conducted a randomized controlled study, in which participants diagnosed with ADHD underwent neurofeedback treatment, and its effects on several cognitive function tests, including the Continuous Performance Test and Stroop were measured. Significant positive results were obtained in continuous performance tasks and Stroop Test for participants underwent neurofeedback training. In Iran, Yaghubi (2010)[50] compared the efficacy of Neurofeedback, Ritalin, and combination therapy in reducing symptoms of children with ADHD. He concluded that Neurofeedback is effective in reducing attention deficit / hyperactivity disorder symptoms and increasing the children's scores on IQ test of Wechsler.

In general, although studies have reported the effectiveness of neurofeedback in improving the performance of children with attention deficit/ hyperactivity disorder, but it should be noted that nowadays neurofeedback has not been accepted as independent or supplement method and its effectiveness as a treatment is not clear. In addition, most of the previous research has limitations due to low sample size, inappropriate sampling, lack placebo group, and lack of randomized assignment of subjects and intervention of treatment methods with each other. As Loo and Barkley (2005) [30] have also expressed, though research conducted in this regard is promising, we still need rigorous and more scientific studies in order to make conclusion in this regard. The present study was conducted to test the effectiveness of the neurofeedback treatment on baseline of quantitative electroencephalography and sustained attention to find objective evidence to judge on confirmation or rejection of effectiveness of this treatment method. Accordingly, it aims to facilitate the evaluation, diagnosis, and monitoring the educational interventions and provide the conditions for educational intervention in school setting.

Hypotheses of study include:

The first hypothesis: qualitative EEG baseline of people who received neurofeedback has arousal level slightly higher compared with the placebo group after training.

The second hypothesis: people who received neurofeedback training have better performance in sustained attention compared with placebo group after training.

**Methodology**

The current study is among the experimental studies conducted in the form of pretest-posttest design with a control group. The population of study included all second to sixth grade elementary students who referred to Psychiatric Clinic in Shiraz to receive treatment. The sample consisted of 30 children who were diagnosed as attention deficit/hyperactivity disorder using clinical interview based on Diagnostic and Statistical Manual of Mental Disorders of American Psychiatric Association (Fifth Edition) by Psychiatric, determining quantitative electroencephalography baseline by an independent clinician, SNAP–IV Classification scale and child behavioral checklist (parent form). In the next step, subjects were screened and they were randomly (using simple random numbers table) divided into two experimental groups and neurofeedback and placebo. In this study, each situation (neurofeedback and placebo) included 15 subjects diagnosed as attention deficit/hyperactivity disorder and inclusion and exclusion criteria of the study included:

A) Children who had one of these conditions were not included in the sample of study:
1. Other psychiatric and neurologic disorders
2. Mental retardation

b) None of the subjects in the experimental group uses drug during the study.

The objective and method of study with details were explained for the subjects and their parents through interview and possible side effects and lack of force to participate in the study were explained for them. In addition, company agreements in the study were announced and confirmed by them through consent form.

**Measurement tools**

**1) Demographic factors questionnaire**

This questionnaire was developed by researchers of the current study and demographic variables such as age, gender, level of education, parental education and parental occupation were investigated.

**2) Raven's Progressive Matrices Test**

Raven's nonverbal test was developed in 1938 by the British psychologist known as Raven. Revised forms of Raven test are used to measure intelligence of people at all levels of ability from children to adults.

All of the questions raised in the matrices are the same and all of them show patterns of images or diagrams to show patterns regulated based on particular logic. Subjects should discover the logic that based on that pattern each question is constructed. Then, they should select the image that completes the question pattern among the images that have been placed blow each pattern as possible option. The test questions have been developed from easy to difficult. The questions content requires the process of mental reasoning to discover the principles and logic governing the relationship between components of patterns of matrices. Therefore, it usually measures the fluid intelligence [51]. The test has 60 questions divided into 5 sections that each of them has 12 questions, and each section questions are ordered from 1 to 12 and the option of each question is numbered from 1 to 6 or from 1 to 8. The time for its implementation is 45 minutes. Reliability coefficient of test in different groups at higher ages is between 0.70 and 0.90. Correlation of this test with other intelligence tests such as the Stanford Bineh and Wechsler is between 0.40 and 0.75. The analysis of several factors in which Raven test was used showed that this test is one of the best indices of the general talent or "g” factor of Spearman and perceptual and spatial factors also partly involved in it [34,52]. Rahmani and Abedi (2004) in the normalization of Raven's Progressive Matrices test for children aged 5 to 10 years in Isfahan examined a sample of 2164 school and preschool students. Based on the results of the test, retest coefficient was obtained 086 and its correlation with Wechsler children IQ test was obtained 0.48.

**3) SNAP–IV rating scale**

SNAP–IV rating scale is a scale used in the diagnosis of Attention Deficit / Hyperactivity disorder that was developed for the first time in 1980 by efforts of Swanson, Nolan, and Pelham based on the behavioral descriptions of attention deficit/ hyperactivity disorder in the third edition of Diagnostic and Statistical Manual of Psychopathy. The scale has 18 questions that parents or teachers can respond to it. The first 9 questions assess inattention behavioral symptoms and the second 9 questions assess behavioral symptoms of often hyperactivity/ impulsivity measure, and finally all 18 questions designed to identify the type of combination. After the implementation, each question is scored from zero to three (never= zero, sometimes= one, often= two, always= three). Then, individual total score is divided by 18 and it is divided in each of the nine sub-types by 9. Cut-off point in total was determined 1.57, 1.1, and 1.9, respectively. This scale has good reliability and validity. Cronbach's alpha coefficient for the total test was determined 0.97 and it was 0.90 and 0.76 for sub-types. Moreover, reliability coefficient of test using test-retest, Cronbach's Alpha coefficients, and split half were determined 0.86, 0.90, and 0.76, respectively [53]. Sadrossadat, Hushyari, Zamani, and Sadrossadat (2010) [54] reported reliability of the test 0.88 by using test-retest, 0.95 by using Cronbach's alpha, 0.73 by using split-half, and its criterion validity was determined 0.55. They obtained cut-off point in the total scale and each of the subscales of attention deficit and hyperactivity 2.08, 2.10, and 2.37, respectively.

In this study, this questionnaire was examined in a preliminary study on a sample of 45 members of children with ADHD and Cronbach's alpha coefficient was used to calculate the reliability coefficient. Cronbach's alpha coefficient for inattention dimension was obtained 0.84, 0.78 for hyperactivity/ impulsivity dimension, and 0.85 for total scale. In addition, test-retest reliability coefficient (with an interval of two months) was obtained 0.84.

**4) Child Behavior Checklist (parent form)**

Child Behavior Checklist (parent form) is another tool that was used in this study. Child Behavior Checklist (Achenbach & Rescorla, 2001) is completed for ages 6 to 18 years by parents and based on status of subject in the last 6 months. Achenbach experience includes a set of parents, teachers, and children forms used for easy and affordable assessing of competencies (abilities), adaptive function, and emotional-behavioral problems. Using these forms, standard data can be easily obtained on a wide range of competencies, adoptive function, and emotional-behavioral problems. Forms of this test are typically completed during 20.25 minutes. If time is limited, we can ask respondents to complete only those parts of the forms that measure competencies and adoptive function or those parts that that rate the emotional-behavioral problems. Scoring the questions is as follows: zero=incorrect, 1=relatively, 2= completely or mainly correct. Cronbach's alpha coefficient for total score has been reported 0.97 and test-retest reliability coefficient was reported 0.94. Alpha coefficients of the scales of competence and adaptive action were between 0.65 and 0.91 in all three forms and alpha coefficients of the scales based on Diagnostic and Statistical Manual Psychiatric Association of America was satisfactory, and it was reported at the range of 0.92 to 0.62. Cronbach's alpha coefficients of the subscales of the problems associated with Attention Deficit / Hyperactivity disorder was reported between 0.78 and 0.92 in all three forms. Yazdkhasti and Arizi (2011) [55] in the normalizing of Child Behavior Checklist in Isfahan concluded that the results showed good validity and reliability of the questionnaire in the case of Isfahan’s children, and the questionnaire was capable to group children into three groups: normal, border, and clinical on eight behavioral and emotional problems from the point of view of father / mother, teacher and children. Therefore, its use along with clinical interview provides the condition for the unbiased diagnosis. In examining the characteristics of the questionnaire, the highest Cronbach's alpha in three versions of father / mother, teacher, and child, was obtained 0.90, 0.93, and 0.82, respectively. Cronbach's alpha, correlation among peer versions, correlation among subscales, and total score of the related section, and cut-off points suggest appropriate construct validity and reliability of these tools to assess the skills and behavior problems in children. The cut-off point for each subscale was between 97.7 and 90% equal to score 70 to 67 T. it means that 7 T-score lower than 67 and higher than 70 and between 67 and 70 indicates normal people, people with behavioral and emotional problems, and people at the clinical border, respectively.

In the present study, in a preliminary study on a sample group of 45 members of children with attention deficit / hyperactivity disorder, psychometric properties of the scale were evaluated. Cronbach's alpha for total test was obtained 0.94 and retest coefficient (with an interval of two months) was obtained 0.91.

**5) Continuous Performance Test**

Continuous performance test (Cornblatt et al., 1988) is a scale for measurement of sustained attention in which a series of number with specified time interval appears on the monitor and two stimuli are determined as target stimulus. The subjects should press the relevant key on the computer screen while they observe the considered number. The target stimulus is relatively scarce (Viswanath, & Reddy, 2008). The test variables are omission error (not pressing the target key in response to stimulus), false alarm error (pressing a key in response to non-target stimuli), reaction time (mean reaction time of correct responses to the stimuli in terms of milliseconds). Omission error and reaction time are associated with attention deficit, false alarm error is associated with impulsivity, speed of information processing is associated with reaction time, and consistency is associated with reaction time variability. In addition, imaging studies have shown the function of frontal lobe activity while testing continuous performance [56]. In its Farsi version, there are 150 numbers or Farsi image as stimulus and among them, 30 stimuli (20%) are considered as target stimulus and 80 % of them are considered as non-target stimulus. The time to provide each stimulus is 200 ms and the time distance between stimuli is 1 second. The time to implement the test is 200 s. according to studies conducted by [57], Farsi form of CPT has good validity and reliability. In their study, the retest reliability value for different parts of the test was between 0.52 and 0.93. The validity of test was determined by using criterion validity and by comparing normal group subjects (30 male school students) and attention deficit / hyperactivity disorder (25 male school students). The statistical comparison of the mean in two groups in different parts of the test showed significant differences between the performance of the two groups and the results of this research are in line with previous research.

In the present study, before the implementation of the research and in preliminary study, test-retest validity test was examined a sample of 45 people suffered from attention deficit / hyperactivity disorder, commission error was 0.82, omission error was 0.79, and reaction time was 0.86.

**6) Assessment of baseline quantitative electroencephalography (EEG)**

Assessment of baseline quantitative electroencephalography (EEG) was conducted by using LXE3204 tool. For each participant, reference electrode was attached to lobe part of right ear back and the main electrode was attached to lobe of left ear back. EEG signals of both channels were taken in the sample frequency of 256 hertz, and they were passed through 0.5 to 50 hertz and they were stored using digital convertor 12 bits in computer. Brain waves of the participants were taken by open eyes so that a situation like neurofeedback training situation to be created. Each of the participants was asked to look at black screen to that stimulus to be neutralized. During the measurement stage, it was tried that body movements and external environment stimuli to be minimized. EEG information was collected and analyzed using Tele Scan Version 3.10. Information indicates digitized absolute values of theta wave (4 to 7 hertz), sensory / motor rhythm (13 to 15 Hertz) and low beta waves (16 to 20 Hertz) for each channel as well as the ratio of theta / wave beta through power spectrum analysis.

**Implementation**

This study was conducted after confirmation and investigation in Faculty of Education and Psychology Review of Shiraz. Neurofeedback training consists of 30 sessions that started from the second week of May 2016 until the first week of September of the same year during the 15 weeks and 2 45-minute sessions per week.

In the experimental neurofeedback situation and to start training, the procedure was firstly explained for child. Then, after regulating the chairs and installing the electrodes, brain waves baseline was recorded. After interpreting the qualitative EEG, the waves required to be strengthened were identified and electrodes and references were attached in the desired locations based on 10-20 system, with use of special glue. The training protocol was so that in which theta band (15 to 20 Hz) was used increasing band firstly, and long beta and theta bands were used as decreasing bands. In the next stage that is in the intervention stage, an animation was presented for children. By distancing brain waves of the children of the desired target, animation was stopped and for re-movement of animation, children were forced to change brain waves in the determined target. By repeating treatment sessions, brain is gradually conditioned to create these changes. The selection of the animations was based on the selection of the children. It should be noted that before starting to work at all sessions, tools such as earrings, necklace, mobile and other devices that might cause problems in the work process were eliminated.

In this study, all subjects of the neurofeedback group were participated in the 30 sessions of the study. In each session, as neurofeedback training group, after regulating the chair, references and electrodes were attached at desired locations on the base of 10-20 system, with special glue and baseline brain waves were recorded. After recording the baseline, neurofeedback device was turned off and while electrodes attached to them, children watched TV only through monitor. After the training, for all participants in both groups, the baseline qualitative EEG and continuous performance test were implemented by an independent therapist, and these tests were implemented again as follow-up test after 8 weeks. After conducting follow-up tests, neurofeedback group subjects (only to participate in the study) underwent 10 sessions of neurofeedback training.

**Findings**

In the present study, the experimental group and the control group according to the research hypothesis were examined in three stages of pre-test, post-test, and follow-up to conclude on the effectiveness of educational intervention of neurofeedback on qualitative EEG baseline and sustained attention according to findings of the study. In this section, first, demographic characteristics of subjects are presented, and then the mean and standard deviation of scores of dependent variables and the results of the using multivariate covariance analysis (MANCOVA) are presented to investigate the research hypotheses.

Descriptive data of the subjects of control and experimental groups based on gender, education level, mean and SD of age and IQ scores of the subjects are shown in Table1. Based on information of table 1, experimental groups were matched in terms of gender and educational level. In addition, the mean age difference ($p<0.98$ and t0.16) and IQ mean difference ($p<0.47$ and $t=0.72$) of the control and experimental groups were not significant.

**Table 1.** Descriptive data of subjects of experimental and control groups based on gender, educational level, age, and IQ

| Variables / groups | | gender | | | Education level | | | | | Age (year) | IQ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | male | female | total | second | third | fourth | fifth | sixth | Mean (SD) | Mean (SD) |
| Experiment | f | 10 | 5 | 15 | 5 | 4 | 2 | 2 | 2 | 9.77 (1.57) | (5.79) 106.53 |
| | % | 66.7 | 33.3 | 100 | 33.3 | 26.7 | 13.3 | 13.3 | 13.3 | | |
| Control | f | 10 | 5 | 15 | 5 | 4 | 2 | 2 | 2 | 9.76 (1.53) | (6.29) 104.93 |
| | % | 66.7 | 33.3 | 100 | 33.3 | 26.7 | 13.3 | 13.3 | 13.3 | | |
| Total | f | 20 | 10 | 30 | 10 | 8 | 4 | 4 | 4 | 9.76 (1.53) | (6.00) 105.73 |
| | % | 66.7 | 33.3 | 100 | 33.3 | 26.7 | 13.3 | 13.3 | 13.3 | | |

**Effects of neurofeedback training on EEG change**

Table 2 shows the mean and standard deviation of the right and left hemispheres of the brain wave activity in experimental and control groups.

**Table 2:** Mean and standard deviation of the right and left hemispheres of the brain wave activity in experimental and control groups

| Variables | groups | **left hemisphere** | | | **right hemisphere** | | |
|---|---|---|---|---|---|---|---|
| | | Pre-test | Psot-test | Follow-up | Pre-test | Psot-test | Follow-up |
| | | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) |
| Theta | Expreoment | (1.88) 14.25 | (1.28) 10.49 | (1.16) 10.61 | (1.60) 12.25 | (1.28) 12.00 | (1.08) 10.11 |
| | Control | (1.42) 14.04 | (1.25) 13.69 | (1.04) 13.69 | (1.40) 12.26 | (1.38) 12.41 | (0.64) 13/31 |
| Beta | Expreoment | (0.90) 5.44 | (0.83)7.73 | (0.70) 7.84 | (0.78) 4.48 | (0.79) 5.02 | (0.81) 5.88 |
| | Control | (0.68) 5.27 | (0.67) 5.22 | (0.62) 5.30 | (0.67) 4.95 | (1.25) 5.13 | (1.07) 4.85 |
| SMR | Expreoment | (0.25) 3.05 | (0.36) 3.28 | (0.34) 3.23 | (0.39) 3.02 | (0.34) 3.21 | (0.36) 3.29 |
| | Control | (0.57) 3.14 | (0.44) 3.20 | (0.45) 3.24 | (0.49) 2.98 | (0.51) 3.06 | (0.46) 3.04 |
| Theta /Beta ratio | Expreoment | (0.57) 2.68 | (0.213) 1/37 | (0.17) 1.35 | (0.61) 2.60 | (1.01) 2.20 | (0.46) 2.13 |
| | Control | (0.46) 2.70 | (0.69)2.83 | (0.37)2.66 | (0.46) 2.51 | (1.61) 4.73 | (0.54) 2.79 |

To determine significant effects of neurofeedback training on brain waves, MANCOVA test was used. It should be noted that prior to conducting the analysis, some of its hypotheses were examined. According to Shapiro-Wilk test, the distribution form of research variables was matched with normal distribution and normality of the data was achieved. Box test was used to assess the hypothesis of equality of covariance equality matrices. Box test results show that theta waves in the left hemisphere (M box test= 1.72, P <0.66), right hemisphere (M box test= 13.70, P <0.06), sensory / motor rhythm of left hemisphere (M box test= 3.12, P <0.41) and the right hemisphere (M box test= 3.12, P <0.41); beta waves of the left hemisphere (M box test= 1.89, P <0.07) and hemisphere right (M box test= 10.02, P <0.26) and the theta / beta ratio in the left hemisphere (M box test= 27.52, P <0.06) and the right hemisphere (M box test= 17.94, P <0.07) are not statistically significant. It indicates that the covariance matrices of the dependent variable to the independent variable levels (groups) are equal. Bartlett's test of sphericity was used for correlation between the dependent sizes, that the results indicate that there was correlation between dependent sizes for MANCOVA analysis. Accordingly, Bartlett test values for theta waves in the left hemisphere (approximate chi square= 1.72, P <0.66), right hemisphere (approximate chi square= 14.79, P <0.0071), sensory / motor rhythm in left hemisphere (approximate chi square= 17.44, P <0.001) and right hemisphere (approximate chi square= 9.04, P <0.01), beta waves in the left hemisphere (approximate chi square= 9.21, P <0.01) and right hemisphere (approximate chi square= 19.81, P <0.001) and the theta / beta ratio in the left hemisphere (approximate chi square= 27.52, P <0.006) and in the right hemisphere (approximate chi square= 39.47, P <0.001) were obtained. To determine the multivariate effect of the independent variable on the dependent variable, Wilks Lambda test was used. Wilks Lambda test value in theta wave activity of the left hemisphere (Partial η2=0.89 and P<0.001, and F (26, 2)=113.60) and the right hemisphere (Partial η2=0.84 and P<0.001, and F (26, 2)=69.07), beta wave in the left hemisphere (Partial η2=0.89 and P<0.001, and F (26, 2)=110.84) and the right hemisphere (Partial η2=0.03 and P<0.63, and F (26, 2)=0.458), the sensor motor rhythm in left hemisphere (Partial η2=0.05 and P<0.44, and F (26, 2)=0.844) and the right hemisphere (Partial η2=0.42 and P<0.001, and F (26, 2)=9.65) theta / beta ratio in the left hemisphere (Partial η2=0.91 and P<0.001, and F (26, 2)=137.94) and the right hemisphere (Partial η2=0.72 and P<0.001, and F (26, 2)=33.49) were obtained. After significance of multivariate tests, covariance analysis test in the context of MANCOVA and in each of the dependent variables was used. In addition, investigating the Levene test for equality of variances of dependent variables of the study showed that the variance of the dependent variables is not significantly different. According to Table 3, it can be said that in the left hemisphere by considering the pre-test scores as a covariate, neurofeedback training intervention led to significant difference between groups in post-test and follow up. In the neurofeedback training group and in the left hemisphere, theta wave activity and theta / beta waves ratio reduced in post-test scores (respectively, F=182.20, P <0.001 and F=85.12, P <0.001). Differential Etta square in the theta brain wave is 0.87 and it is 0.75 in ratio of theta / beta. In other words, 87 percent of theta variance and 75 percent of theta / beta ratio in post-test related to applying the independent variable (neurofeedback training intervention) and the difference was found between the groups in terms of theta wave activity and theta / beta waves ratio in scores of follow up test (respectively: F= 186.63, P <0.001 and F=264.00, P <0.001). In addition, in the follow-up tests, differential Etta square for theta brain wave was 0.87 and it was 0.90 in the theta / beta ratio. In addition, based on the results obtained, beta wave activity in the post-test (respectively: F=157.30, P <0.001) and in the follow-up test (F=132.95, p<0.001) increased significantly compared to pre-test. The results of differential Etta square indicate that 85% of the post-test variance and 87% of the variance of follow-up related to applying the independent variable (neurofeedback training intervention). Considering the sensory / motor rhythm, results indicate that despite an increase in post-test and follow-up test scores, there was no statistically significant difference (Table 3).

**Table 3:** The results of covariance analysis in the context of MANCOVA to compare the experimental and control groups in the left hemisphere brain waves (post-test and follow-up)

| scale | index source of changes | Dependent variable | Sum of squares | df | Mean squares | F | Significance level | Differential Etta |
|---|---|---|---|---|---|---|---|---|
| theta | Pre-test | Post-test | 31.12 | 1 | 31.12 | 58.52 | 0.001 | 0.68 |
| | | Follow-up test | 21.79 | 1 | 21.79 | 46.97 | 0.001 | 0.63 |
| | Group | Post-test | 96.89 | 1 | 96.89 | 182.20 | 0.001 | 0.87 |
| | | Follow-up test | 86.56 | 1 | 86.56 | 186.63 | 0.001 | 0.87 |
| | error | Post-test | 14.35 | 27 | 0.53 | | | |
| | | Follow-up test | 12.52 | 27 | 0.46 | | | |
| | Total | Post-test | 4619.86 | 30 | | | | |
| | | Follow-up test | 4627.19 | 30 | | | | |
| beta | Pre-test | Post-test | 8.91 | 1 | 8.91 | 33.07 | 0.001 | 0.55 |
| | | Follow-up test | 6.17 | 1 | 6.17 | 27.28 | 0.001 | 0.50 |
| | Group | Post-test | 42.32 | 1 | 42.32 | 157.03 | 0.001 | 0.85 |
| | | Follow-up test | 44.19 | 1 | 44.19 | 132.95 | 0.001 | 0.87 |
| | error | Post-test | 7.27 | 27 | 0.27 | | | |
| | | Follow-up test | 6.11 | 27 | 0.22 | | | |
| | Total | Post-test | 1323.54 | 30 | | | | |
| | | Follow-up test | 1357.82 | 30 | | | | |
| Sensory/motor rithem | Pre-test | Post-test | 2.04 | 1 | 2.04 | 20.67 | 0.001 | 0.43 |
| | | Follow-up test | 2.12 | 1 | 2.12 | 24.19 | 0.001 | 0.47 |
| | Group | Post-test | 0.13 | 1 | 0.135 | 1.36 | 0.250 | 0.04 |
| | | Follow-up test | 0.01 | 1 | 0.012 | 0.133 | 0.710 | 0.00 |
| | error | Post-test | 2.67 | 27 | 0.09 | | | |
| | | Follow-up test | 2.37 | 27 | 0.08 | | | |
| | Total | Post-test | 321.12 | 30 | | | | |
| | | Follow-up test | 319.03 | 30 | | | | |
| Theta/beta ratio | Pre-test | Post-test | 2.35 | 1 | 2.35 | 12.70 | 0.001 | 0.32 |
| | | Follow-up test | 1.06 | 1 | 1.06 | 22.26 | 0.001 | 0.45 |
| | Group | Post-test | 15.81 | 1 | 15.81 | 85.12 | 0.001 | 0.75 |
| | | Follow-up test | 12.62 | 1 | 12.62 | 264.00 | 0.001 | 0.90 |
| | error | Post-test | 5.01 | 27 | 0.18 | | | |
| | | Follow-up test | 1.29 | 27 | 0.04 | | | |
| | Total | Post-test | 156.05 | 30 | | | | |
| | | Follow-up test | 136.09 | 30 | | | | |

Based on the results presented in Table 4, it could be stated that by considering the pre-test scores as covariate, Neurofeedback training intervention in children with attention deficit / hyperactivity leads into significant difference between control and experimental groups in the bran waves of theta, theta/beta and sensory/motor rhythm in the right hemisphere in the post-test stage. According to information obtained, the activity of theta wave and the ratio of theta/beta reduced in posttest scores (respectively: F=49.79, P <0.001 and F=27.28, P <0.001). Differential Etta square shows the rate of the effect, and it is 0.64 in the theta brain wave and 0.50 in the theta / beta ratio, and the difference in follow-up test scores continued (respectively: F=140.39, P <0.001 F=35.01, P <0.001). In follow-up tests, differential chi square for theta brain wave was 0.83 and it was 0.56 for the theta / beta ratio. In addition, based on the results, sensory / motor activity score in the post-test (P<0.01, F=7.08) and in the follow-up test (F=20.02, p<0.01) increased significantly compared to pre-test score. In this regard, differential Etta square test analyses show that 21% and 42% of the variance of the post-test and 42 percent of follow-up test variance related to applying the independent variable (neurofeedback training intervention). In the case of brain waves of beta, results indicate that despite an increase in scores of post-test and follow-up test, the beta level was not a significantly different.

**Table 4:** results of analysis of variance test in the MANCOVA context to compare experimental and control groups in right hemisphere brain waves (post-test and follow-up)

| Sub-scale | Source of changes | Dependent variable | Sum of squares | df | Mean squares | F | Sig | Differential Etta |
|---|---|---|---|---|---|---|---|---|
| theta | Pre-test | Post-test | 26.32 | 1 | 26.32 | 30.34 | 0.001 | 0.52 |
| | | Follow-up test | 9.98 | 1 | 9.98 | 22.07 | 0.001 | 0.45 |
| | Group | Post-test | 43.20 | 1 | 43.20 | 49.79 | 0.001 | 0.64 |
| | | Follow-up test | 63.48 | 1 | 63.48 | 140.39 | 0.001 | 0.83 |
| | error | Post-test | 23.42 | 27 | 0.86 | | | |
| | | Follow-up test | 12.20 | 27 | 0.45 | | | |
| | Total | Post-test | 3861.91 | 30 | | | | |
| | | Follow-up test | 4104.22 | 30 | | | | |
| beta | Pre-test | Post-test | 21.49 | 1 | 21.49 | 61.58 | 0.001 | 0.69 |
| | | Follow-up test | 16.42 | 1 | 16.42 | 49.67 | 0.001 | 0.64 |
| | Group | Post-test | 0.004 | 1 | 0.004 | 0.01 | 0.92 | 0.00 |
| | | Follow-up test | 0.179 | 1 | 0.176 | 0.54 | 0.46 | 0.02 |
| | error | Post-test | 9.42 | 27 | 0.34 | | | |
| | | Follow-up test | 8.92 | 27 | 0.33 | | | |
| | Total | Post-test | 805.20 | 30 | | | | |
| | | Follow-up test | 736.27 | 30 | | | | |
| Sensory/motor rithem | Pre-test | Post-test | 4.98 | 1 | 4.98 | 387.84 | 0.001 | 0.93 |
| | | Follow-up test | 4.44 | 1 | 4.44 | 253.12 | 0.001 | 0.90 |
| | Group | Post-test | 0.09 | 1 | 0.09 | 7.08 | 0.01 | 0.21 |
| | | Follow-up test | 0.35 | 1 | 0.35 | 20.02 | 0.01 | 0.42 |
| | error | Post-test | 0.34 | 27 | 0.01 | | | |
| | | Follow-up test | 0.47 | 27 | 0.01 | | | |
| | Total | Post-test | 301.85 | 30 | | | | |
| | | Follow-up test | 305.97 | 30 | | | | |
| Theta/beta ratio | Pre-test | Post-test | 2.24 | 1 | 2.24 | 1.24 | 0.27 | 0.04 |
| | | Follow-up test | 4.03 | 1 | 4.03 | 35.71 | 0.001 | 0.56 |
| | Group | Post-test | 49.25 | 1 | 49.25 | 27.28 | 0.001 | 0.50 |
| | | Follow-up test | 3.95 | 1 | 3.95 | 35.01 | 0.001 | 0.56 |
| | error | Post-test | 48.74 | 27 | 1.80 | | | |
| | | Follow-up test | 3.04 | 27 | 0.11 | | | |
| | Total | Post-test | 406.360 | 30 | | | | |
| | | Follow-up test | 192.97 | 30 | | | | |

**Continuous Performance Test**

Table 5 shows the performance of experiment and control groups in subscales of Continuous Performance Test. MANCOVA analysis was used to assess the statistical significance of the differences. Before conducting the analysis, the establishment of some of the most important hypotheses was examined. According to Shapiro-Wilk test, distribution form of variables was matched with normal distribution. Box test was used to assess the hypothesis of equality of MANKOVA indices. The results showed that in the index of commission error, Continuous Performance Test (M box test= 8.77, P <0.06), omission error (Box's M= 8.77, P <0.06), and reaction time (Box's M= 8.77, P <0.06) was not statistically significant. It suggests that MANCOVA matrices of the dependent variable are equal to the independent variable levels (groups). Bartlett's test of sphericity was used for correlation between the sizes of the dependent variables, and the results indicate sufficient correlation between the dependent sizes to conduct MANCOVA analysis. Accordingly, Bartlett test values were obtained for commission error index (approximate chi square= 3.75, P <0.04), omission error (approximate chi square= 25.55, P <0.001), and reaction time (approximate chi-square=63.39 P <0.001).

To study the multivariate effect of independent variables on the dependent variable, Wilks Lambda test was used. Wilks Lambda criterion in the commission error of Continuous Performance Test was (Partial $\eta2$= 0.74 and P<0.001, and F (2, 26) = 38.81), it was (Partial $\eta2$=0.51 and P<0.001, and F (2, 26)=13.74) in the omission error. It was also (Partial $\eta2$=0.89 and P<0.01, and F (2, 26)=4.94) in reaction time. The significance of the results shows that neurofeedback treatment has been effective on a dependent variable.

The results of inter-group effects tests to evaluate significance of each of the dependent variables showed that by considering pre-test scores as covariate, neurofeedback training intervention led to a significant difference between in post-test and follow-up test. In the neurofeedback group, commission error, omission error, and mean reaction time in compared to pre-test, post-test (respectively: F=43.04, P <0.001, F= 14.83, P <0.001 and F= 7.01, p<0.01) and follow up (respectively: F=63.42, P <0.001, F= 28.26, P <0.001 and F= 9.38, p<0.005) showed a significant decrease (table 6).

**Table 5:** Mean and standard deviation of sub-scales of continuous performance test in the control and experimental groups

| Sub-scales | groups | Pre-test | Post-test | Follow-up test |
|---|---|---|---|---|
| | | Mean (SD) | Mean (SD) | Mean (SD) |
| commission error | Experiment | (2.61) 13.533 | (1.81) 10.000 | (1.86) 9.933 |
| | Control | (3.07) 15.000 | (3.12) 14.933 | (2.76) 16.266 |
| omission error | Experiment | (1.78) 6.800 | (1.95) 4.333 | (1.38) 4.933 |
| | Control | (2.41) 9.666 | (2.64) 4.66 | (2.37) 10.266 |
| Reaction time | Experiment | (4.49) 83.066 | (9.28) 77.800 | (9.22) 77.800 |
| | Control | (6.63) 84.933 | (6/74) 86.133 | (6.27) 86.733 |

**Table 6:** Results of covariance analysis test in the context of MANCOVA to compare the experimental and control groups in the Continuous Performance Test (post-test and follow-up)

| Scale | Source | Dependent variable | Sum of squares | df | Mean squares | F | Sig | Partial Eta Squared |
|---|---|---|---|---|---|---|---|---|
| commission error | Pre-test | Post-test | 116.66 | 1 | 116.66 | 47.53 | 0.001 | 0.63 |
| | | Follow-up test | 63.79 | 1 | 63.79 | 18.70 | 0.01 | 0.40 |
| | Group | Post-test | 105.63 | 1 | 105.66 | 43.04 | 0.001 | 0.61 |
| | | Follow-up test | 216.28 | 11 | 216.28 | 63.42 | 0.001 | 0.70 |
| | error | Post-test | 66.26 | 27 | 2.45 | | | |
| | | Follow-up test | 92.07 | 27 | 3.41 | | | |
| | Total | Post-test | 5028.00 | 30 | | | | |
| | | Follow-up test | 56.05.00 | 30 | | | | |
| omission error | Pre-test | Post-test | 59/28 | 1 | 59.28 | 17.43 | 0.001 | 0.39 |
| | | Follow-up test | 38/01 | 1 | 38.01 | 15.12 | 0.001 | 0.35 |
| | Group | Post-test | 50.41 | 1 | 50.41 | 14.83 | 0.001 | 0.35 |
| | | Follow-up test | 71.04 | 11 | 71.04 | 28.26 | 0.001 | 0.51 |
| | error | Post-test | 91.78 | 27 | 3.40 | | | |
| | | Follow-up test | 67.85 | 27 | 2.51 | | | |
| | Total | Post-test | 1777.00 | 30 | | | | |
| | | Follow-up test | 2052.00 | 30 | | | | |
| Reaction time | Pre-test | Post-test | 484.56 | 1 | 484.56 | 9.62 | 0.004 | 0.26 |
| | | Follow-up test | 642.22 | 1 | 642.00 | 10.32 | 0.003 | 0.27 |
| | Group | Post-test | 353.41 | 1 | 353.41 | 7.01 | 0.013 | 0.20 |
| | | Follow-up test | 420.47 | 11 | 420.47 | 9.38 | 0.005 | 0.25 |
| | error | Post-test | 1359.57 | 27 | 50.35 | | | |
| | | Follow-up test | 1209.11 | 27 | 44.78 | | | |
| | Total | Post-test | 203921.00 | 30 | | | | |
| | | Follow-up test | 205304.0 | 30 | | | | |

**Discussion and conclusion**

This study was conducted to investigate the effects of qualitative EEG neurofeedback and sustained attention in children with attention deficit / hyperactivity disorder. With regard to the fact that children with attention deficit / hyperactivity disorder in comparison with normal children have higher slow brain wave activity (theta) and lower beta activity, neurofeedback aims to train the patients to normalize their brain wave reactions to stimuli. Therefore, the main goal of neurofeedback is to change brain performance through EEG training. In fact, the brain is trained and the focus of this training is on gradual learning of increase in the level of some EEG components or reducing the other components.

The first hypothesis states that the qualitative EEG baseline of people underwent neurofeedback have higher arousal level compared to placebo group after training. Based on the results, this hypothesis was confirmed. Current results are consistent with previous findings [25, 31, 35, 44, 58] on children with attention deficit / hyperactivity disorder. Research has shown that increasing the slow brain waves (less than 10 Hz) in different areas of the brain is associated with foggy thinking, slow reaction times, counting failure, poor judgment, lack of impulse control, and reduced attention and arousal in women. It is expected that by suppression or reduction of theta wave in the central region of the skull, we can observe the change in brain waves and change in behavior, particularly an increase in arousal and attention in people with ADHD. Therefore, it can be concluded that neurofeedback training can help people with hyperactivity disorder in regulating brain wave activity, and thereby, improve their problems. Similarity of the results of these results with findings of previous studies reflects the base of neurofeedback training. Thorndike law states that positive feedback of a response increases the reaction probability occurrence. In neurofeedback training, participants consider feedback as a positive change in the game, when reducing the theta wave activity, the ratio of theta/ beta waves, sensory / motor rhythm improvement, or reduction in beta wave activity. Conversely, if the ratio of beta / theta wave increases, participants in the game receive negative feedback. In this study, subjects of neurofeedback group learned to increase the EEG activity based on positive feedback or reduce negative feedback. In neurofeedback group, sensory / motor rhythmic wave activity on the right and left hemispheres increased. In addition, log effect after follow-up did not lead to significant reduction at the level of brain waves and the results of follow-up test had significant difference with results of pre-test. Yu (2015) states that longer-term training may be essential to change the effect of sensory / motor rhythm change. Theta is associated with impulsivity, distractibility, inattention, and anxiety and investigation of brain waves of children with Attention Deficit / Hyperactivity disorder represents the extreme theta in these children. Neurofeedback experts accordingly train the theta reduction protocol, suppress the neurofeedback of this rhythm, and facilitate the growth of the brain.

The second hypothesis suggests that sustained attention performance test enhances with neurofeedback training. The obtained results confirmed this hypothesis. In line with results of previous studies [32, 33, 49], this research suggests a significant reduction in omission error, commission errors, and reaction time in the post-test and follow up tests. The main measures of the Continuous Performance Test include omission error and commission error. Commission error assesses the impulsivity as an error responding to non-target stimulus, and omission error evaluates the inattention as error that ignores the target stimulus. These results can be interpreted that children with attention deficit / hyperactivity disorder have more problems in sustained attention compared with normal children and the probability of inhibition disorder (for example, impulsivity) is more in them. In addition, cognitive functions are associated with brain wave activity. A comparison between EEG and continuous performance of children with attention deficit / hyperactivity disorder and normal children indicates that children with this disorder have shown stronger activity in the theta wave and weaker activity in beta wave compared to normal children. In addition, their performance in Continuous Performance Test has been less than that in normal children. The main symptoms of attention deficit / hyperactivity disorder can be considered as an evidence in the objective attention test in moment feedback based neurofeedback training that includes reduced activity in the theta wave and improved beta wave activity. Information of the present research implies that neurofeedback training increases brain arousal by reducing the activity of theta waves and ratio of theta / beta and increasing beta waves and sensory / motor rhythm, in children with attention deficit / hyperactivity disorder. These changes are effective in normalizing the abnormal EEG of children with attention deficit / hyperactivity disorder as well as improving sustained attention measured by Continuous Performance Test.

It is hoped that the current information to provide the conditions for future studies related to neurofeedback training. However, drug therapy is an initial strategy for attention deficit / hyperactivity disorder. However, drug therapy may not be effective and have side effects and parents due to drug prescription, parent may do not have the desire to visit psychiatrist. According to the results of the study, neurofeedback training alone can improve brain arousal level and sustained attention in children with ADHD. Therefore, this study is a noninvasive and easy procedure for children with ADHD.

In total, according to the results, we can say that neurofeedback training has the capability to normalize the brain waves of children with attention deficit / hyperactivity disorder. This learning helps the brain to learn how to regulate itself and resolve its functional problems. As a result, it can improve the performance and improve the sustained attention of the children. Studies have shown that increased brain slow waves in various areas of the brain are associated with foggy thinking, slow reaction time, failure in counting, poor judgment, lack of impulse control, and reduced attention, and arousal in people. Therefore, it is expected that by suppressing or reducing theta wave in the central area of the skull, we observe change in behavior, especially increased arousal and attention in people. Therefore, it can be concluded that neurofeedback training can help people with attention deficit / hyperactivity disorder in regulating the activity of their brain waves and thereby improving their attention problems.

There are several limitations to this study. First, this study evaluates only partial lobe of EEG FOR C3 and C4 regions. However, inattention, impulsivity, and hyperactivity in attention deficit disorder / hyperactivity disorder may affect several areas of the brain. Therefore, future research should examine the EEG related to all brain areas. Second, further research should be conducted with more subjects to determine the effectiveness of neurofeedback treatment on different subtypes of attention deficit disorder / hyperactivity. Finally, neurofeedback training sessions lack diversity for sensory / motor rhythm and 30 sessions in this study to improve the rhythm of sensory / motor in both hemispheres has been inadequate, so increasing the number of sessions to 45 sessions is recommended for future research.

**References**

1. American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (5 nd ed). Arlington, VA: American Psychiatric Publishing.
2. Barkley, R. A. (2015). Attention-deficit hyperactivity disorder: A handbook for diagnosis and treatment (4th ed.). New York, NY: Guildford Press.
3. Gupta, R., & Kar, B. R. (2009). Development of attentional processes in ADHD and normal children. Progress in Brain research, 176, 259-76.
4. Visser, S. N., Danielson, M. L., Bitsko, R. H., Holbrook, J. R., Kogan, M. D., Ghandour, R. M., Perou, R., & Blumberg, S. J. (2013). Trends in the parentreport of health care provider-diagnosed and medicated attention-deficit/hyperactivity disorder: United States, 2003-2011. Journal of American Academic Child Adolescent Psychiatry, 53, 34-46.
5. Hagaman, Jessica L, & Casey, Kathryn J. (2016). Understanding and supporting the academic needs of students with ADHD. Special ugdymas/ special education, 1(34).
6. Biederman, J. & Faraone, S. V. (2005). Attention-deficit hyperactivity disorder.Lancet, 366(9481), 237-248.
7. De Graaf, R., Kessler, R. C., Fayyad, J., ten Have, M., Alonso, J., & Angermeyer, M. (2008). The prevalence and effects of adult attention-deficit/hyperactivity disorder (ADHD) on the performance of workers: results from the WHO World Mental Health Survey Initiative.
8. Lee, S. S., Humphreys, K. L., Flory, K., Liu, R. & Glass, K. (2011). Prospective association of childhood attention - deficit/hyperactivity disorder (ADHD) and substance use and abuse/dependence: a meta-analytic review. Clinical Psychology Review, 31(3), 328-341.
9. De Zwaan, M., Gruss, B., Muller, A., Graap, H., Martin, A., & Glaesmer, H. (2012). The estimated prevalence and correlates of adult ADHD in a German community sample. European Archives of Psychiatry and Clinical Neuroscience, 262(1), 79-86.
10. Birchwood, J., & Daley, D. (2012). Brief report: The impact of attention deficit hyperactivity disorder (ADHD) symptoms on academic performance in an adolescent community sample. Journal of Adolescence, 35, 225-231.
11. Brock, S. E., Jemerson, S. R., & Hansen, R. L. (2009).Developmental sychopathological at school: Identifying, assessing and treating ADHD at school, Springer.
12. Barkley. R. A. (2000). Genetics of Childhood disorders. XVII. ADHD, Part 1: The executive functions and ADHD. Journal of the American of Child and Adolescent Psychiatry, 39, 1064-1068.
13. Barkley, R.A. (2005). ADHD and the nature of selfcontrol. New York: Guilford Press.
14. Barkley, R. A. (2006). Attention-deficit hyperactivity disorders A handbook for diagnosis and treatment. (3th ed.). New York: Guilford Press.
15. Barkley, R. A. (2013). Distinguishing sluggish cognitive tempo from ADHD in children and adolescents: executive functioning, impairment, and comorbidity. Journal of Clinical Child and Adolescent Psychology, 42, 161-173.
16. Nigg, J. T. (2006). What causes ADHD? Understanding what goes wrong and why. New York: Guilford Press.
17. Welsh, M. C., & Pennington, B. F. (1998). Assessing frontal lobe functioning in children: Views from developmental psychology. Developmental Neuropsychology, 4, 199-230.
18. Brown, T.E. (2005). Attention deficit disorder: the unfocused mind in children and adults. New Haven: Yale University Press.
19. Brown, T.E. (2006). Executive functions in attention deficit hyperactivity disorder: Implications of two conflicting views. International Journal of Disability, Development, and Education, 53, 35-46.
20. Sonuga-Barke, E. J. S., Sergeant, J. A., Nigg, J. & Willcutt, E. (2008). Executive dysfunction and delay aversion in attention deficit hyperactivity disorder: nosologic and diagnostic implications. Child and Adolescent Psychiatric Clinics of North America, 17,367-384.
21. Nakao, T., Radua, J., Rubia, K., & Mataix-Cols, D. (2011). Gray Matter Volume Abnormalities in ADHD: Voxel-Based Meta-Analysis Exploring the Effects of Age and Stimulant Medication. American Journal of Psychiatry, 168, 1154-1163.
22. Hill, E. L., & Bird, C. M (2006). Executive processes in Asperger syndrome: patterns of performance in a multiple case series. Neuropsychologia. 44(14):2822-35.
23. Hill, R., & Castro, E. (2002). Getting Rid of Ritalin: How Neurofeedback Can Successfully Treat Attention Deficit Disorder Without Drugs. Charlottesville, VA: Hampton Roads.
24. Toplak, M. E., Dockstader, C., & Tonnock, R. (2006). Temporal information processing in ADHD: Findings to date and new methods. Journal of Neuroscience Methods, 151, 15-29.
25. Barkley, R. A. & Murphy, K. R. (2010). Impairment in occupational functioning and adult ADHD: the predictive utility of executive function (EF) ratings versus EF tests. Archives of Clinical Neuropsychology, 25(3), 157-173.
26. Barkley R. A. (1997). Attention-defieit hyperactive disorder: A handbook for diagnosis and treatment (2 ed). New York: Guilford Press.
27. Mcgee, R., Brodeur, D., Symons, D., Andrade, B., & Fahie, C. (2004). Time perception: Does it distinguish ADHD and RD children in a clinical sample? Journal of Abnormal Child Psychology, 32(5), 481-490.
28. Lansbergen, Arns, van Dongen-Boomsma, Spronk., & Buitelaar. (2011). the increase in theta/beta ratio on resting-state EEG in boys with attention-deficit/hyperactivity disorder is mediated by slow alpha peak frequency. Neuropsychopharmacol Biol Psychiatry.15; 35(1):47-52.

29. El-Sayed, E., Larsson, J.o., person, H. E., & Redelius, P. A. (2002).Altered Cortical activity in children with attention deficit/ hyperactivity disorder during attentional load task. Journal of American Academy of Child and Adolescent Psychiatry, 41, 811-819.
30. Loo, S. K., & Barkley, R. K. (2005). Clinical utility of EEG in ADHD. Applied Neuropsychology. 12 (2), 64- 76.
31. Masterpasque, F., Healey, K. N. (2003). Neurofeedback in Psychological practice professional psychology: Research and Practice, 34(6), 651- 656.
32. Bink, M., van Nieuwenhuizen, C., Popma, A., Bongers, I. L., & van Boxtel, G. J. M. (2014). Neurocognitive effects of neurofeedback in adolescents with ADHD: a randomized controlled trial. The Journal of Clinical Psychiatry, 75(5), 535–542.
33. Arns M, Heinrich H, Strehl U. (2014). Evaluation of neurofeedback in ADHD: the long and winding road. Biol Psychol; 95: 108–15.
34. Vernon, D., Egner, T., Cooper, N., et al (2003). The effect of training distinct neurofeedback protocols on aspects of cognitive performance. International Journal of Psychophysiology, 47, 75-85.
35. Ryoo, ManHee., Son, ChongNak (2015). Effects of Neurofeekback Training on EEG, Continuous Performance Task (CPT), and ADHD Symptoms in ADHD-prone College Students. J Korean Acad Nurs Vol.45 No.6, 928- 938.
36. Wang, J.-R., & Hsieh, S. (2013). Neurofeedback training improves attention and working memory performance. Clinical Neurophysiology: Official Journal of the International Federation of Clinical Neurophysiology, 124(12), 2406–2420.
37. Gruzelier, J. H. (2014a). EEG-neurofeedback for optimising performance: A review of cognitive and affective outcome in healthy participants. Neuroscience & Biobehavioral Reviews, 44, 124–141.
38. Klimesch, W. (1999). EEG alpha and theta oscillations reflect cognitive and memory performance: a review and analysis. Brain Research Reviews, 29(2–3), 169–195.
39. Gruzelier, J. H. (2014b). EEG-neurofeedback for optimising performance. III: a review of methodological and theoretical considerations. Neuroscience and Biobehavioral Reviews, 44, 159–182.
40. Lee, S. W. (1991). Biofeedback as a treatment for childhood hyperactivity: A critical review of the literature. Psychological Report, 68 (1), 37-42.
41. Thompson, L., & Thompson, M. (1998). Neurofeedback combined with training in metacognitive strategies: Effectiveness in students with ADD. Applied Psychophysiology Biofeedback, 23, 243-263.
42. Carmody, D. P., Radvansik, D.C., Wadhwani, S., Sabo, M. J., &Vergara, L. (2001) EEG biofeedback training and attention deficit hyperactivity disorder in an elementary school setting. Journal of Neurotherapy, 4(3), 5-27.
43. Beauregard, M., & Levesque, J. (2006). Functional magnetic resonance imaging investigation of the effects of neurofeedback training on the neural bases of selective attention and response inhibition in children with attention-deficit/hyperactivity disorder. Applied Psychophysiology and Biofeedback, 31(1), 3–20.
44. Bakhshayesh, A. R., Schneider, A., Wyschkon, A., Es ser, G., & Ihle, W. (2007). Effectiveness of neurofeedback therapy in the treatment of attention deficit hyperactivity disorder (ADHD). The 5th World Congress of Behavioural & Cognitive Therapies, Abstract Band, Barcelona, Spain.
45. Lubar, J. F., & Shouse, M. N. (1976). EEG and behavioral changes in a hyperkinetic child concurrent with training of the sensorimotor rhythm (SMR): A preliminary report. Biofeedback and Self-Regulation, 1(3), 293–306.
46. Rossiter TR, LaVaque TJ. (1995). A comparison of EEG biofeedback and psychostimulants in treating attention deficit/hyperactivity disorders. Journal of Neurotherapy. 1(1): 48-59.
47. Nash. J. (2001). Adverse reactions and potential iatrogenic effects in neurofeedback training. Journal of Neurotherapy, 4(4), 57- 69.
48. Wangler, S., Gevensleben, H., & Albrecht, B. (2011). Neurofeedback in children with ADHD: p Secific event-related potential findings of a randomized controlled trial. Clinical Neurophysiology, 122(12), 942-950.
49. Zoefel B, Huster R. J., & Herrmann C, S (2011). Neurofeedback training of the upper alpha frequency band in EEG improves cognitive performance. Neuroimage; 54 (2):1427-31.
50. Yaghubi, H. (2006). Comparison of the effectiveness of interactive feedback and Ritalin in reducing symptoms of attention deficit / hyperactivity disorder, clinical psychology doctoral dissertation, unpublished, Tehran University of Social Welfare and Rehabilitation Sciences.
51. Sharifi, HP (1997). Theory and Application of Intelligence and Personality tests. Tehran, Sokhan Publications
52. Marnat, G (1990). Handbook of Psychological Assessment. Translated by Sharif Pasha and Nikkhooi (2008). Tehran, Roshd Publications
53. Bussing, R., Fernandez, M., Harwood, M., Hou, H., Garvan, C.W., Eyberg, S. M., & Swanson, J. M. (2008). Parent and teacher SNAP-IV Ratings of Attention Deficit Hyperactivity Disorder Symptoms: Psychometric properties and normative ratings from a school district sample. Assessment, 15, 317-328.
54. Sadrossadat, SJ; Hushyari, Z; Zamani, R and Sadrossadat, L. (2010). Determining psychometric properties of SNAP-IV rating scale, the implementation of the parents. Rehabilitation 3, 65-60.
55. Yazdkhasti, F and Arizi, HR (2011). Standardization of three versions of children, father / mother and teacher in Isfahan Child Behavior Checklist. Iranian Journal of Psychiatry and Clinical Psychology, 17 (1), 70-60.
56. Kramer, A. F., Hahn, S., Cohen, N. J., Banich, M. T., (1999). Ageing, fitness and neurocognitive function. Nature, 400: 418-419.
57. Hadianfard, H; Najarian, B; Shokrkon, H, Mehrabizadeh,, M. (2000). Procurement and construction of Persian form of continuous performance test. Journal of Psychology, 4, 388-404.
58. Lubar, J. F (2003). Neurofeedback for the management of attention deficit disorder: A practice guide. NewYour: Gilford Press