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Research Article

PRELIMINARY EFFICACY OF A NEW COMPUTERIZED PROGRESSIVE ATTENTION TRAINING PROGRAM IN CHILDREN WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER

[*]Soroush Bakhshi[1], Fatemeh Behnia[1], Vahid Nejati[2] and Ebrahim Pishyareh[1]
[1]Department of Occupational Therapy, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran
[2]Department of Psychology, Faculty of Human Science, Shahid Beheshti University, Tehran, Iran
[*]Author for Correspondence

ABSTRACT
This study was aimed to investigate the effectiveness of the selected attention tasks on sustained attention performance in children with Attention Deficit Hyperactivity Disorder. Eighteen children with ADHD were selected from different psychiatry and occupational therapy clinics of Tehran, and were randomly divided into experiment and control groups. The experiment group participant's received 10 one-hour computerized attention training sessions. The participants in the control group were in the waiting list during the study. All participants were tested by Continuous Performance Test and Conner's Rating Scale before and after the intervention. The results showed a significant difference in the performance of sustained attention (P=0.000) and impulsivity level (P=0.021). Changes in "mean reaction time" did not show statistical significance. Significant differences was observed in total score (P=0.000), subscale of learning problems (P=0.003), and hyperactivity index (P=0.000) in the Conner's Rating Scale. The results indicate that the performance of sustained attention in ADHD children may be improved by computerized attention training.

Keywords: *Attention Deficit Hyperactivity Disorder, Sustained Attention, Attention Training*

INTRODUCTION
Attention Deficit Hyperactivity Disorder (ADHD) with the prevalence of 5-7% is one of the most common psychiatric disorders of childhood (Kaplan and Sadock, 2005). Main symptoms include deficit in attention performances causes many problems during educational period, such as taking poor scores and incompetency in fulfilling academic tasks (Vile *et al*, 2006). Moreover, ADHD is in many cases accompanied by learning disorder, such that 70% of the children with the disorder have different learning disorders, too. This causes an increase in children's educational problems (Brock *et al.,* 2009). There is wide range of therapeutic methods for ADHD, including medical treatment, behavioral therapy, cognitive treatments, family interventions, special trainings, and multi-dimensional treatments (Purdie *et al.,* 2002). Among the mentioned methods, the cognitive-approach interventions include cognitive interventions, cognitive-behavioral interventions, and neural-based interventions (Toplak *et al.*, 2008).
"Attention" is considered as one of the cognition components, and is divided into different types including focused attention, selective attention, sustained attention, alternative attention, and divided attention. Among the stated types, sustained attention is defined as the ability of doing a goal-oriented behavior in a repetitive continuous activity in a period of time. Posner introduces three separate, but interrelated attention networks as the brain attention networks, including spatial orienting of attention network, target selection and conflict resolution network, and vigilance network, which is sometimes expressed as sustained attention network. In the model, the performances of sustained attention are carried out by right prefrontal areas and nor epinephrine system (Sohlberg and Mateer, 2001).
Cognitive-based intervention is regarded as one of the common therapeutic methods of ADHD (Toplak, *et al.,* 2008). Most attention training programs are based upon the fact that by providing opportunity of stimulating different aspects of attention, the individual's attention ability will be improved. These different aspects of attention are so various, and are consistent with the attention model, the program is based upon. In this paper, treatment includes tasks that have attention requirements. Repetition of these

tasks and exercises facilitate changes in cognitive capacity. Attention training has been considered in some studies (Sohlberg and Mateer, 2001).

Kerns *et al.,* (1999) studied the efficiency of an attention training program, named "pay attention"; carried out on 14 children in the age range of 7-11with ADHD, and after 8 weeks of intervention, including two 30-minute sessions in each week, they reported improvement in attention and also academic performances in the experiment group (Kerns *et al.*, 1999) which indicated treatment transfer to general attention in children academic tasks. Shalev *et al*., (2007) applied a computerized progressive training program, and showed the improvement of academic performances and decrease in inattention symptoms in ADHD children (Shalev *et al.,* 2007). In another research Najafi *et al.,* (2006) investigated the effect of computer typing training and computer games on inattentiveness and impulsivity symptoms of children with ADHD. The results showed impulsivity decrease in the computer typing training group only (Najafi *et al.*, 2006). In another research, White *et al.,* (2006) showed increase in alternative attention performance in adults with ADHD after two 1-hour sessions (White and Shah, 2006). Kurtz *et al.,* used attention process training program to reinforce attention performance in patients with schizophrenia and demonstrated a significant improvement in attention training group, in terms of sustained attention and divided attention (Kurtz *et al.,* 2001).

Moreover, in another study, Kurtz et al. studied the effect of a computer-based cognitive intervention in adults with schizophrenia, and after 100 hours of computerized intervention, they reported significant improvement in attention scales and working memory in the experiment group (Kurtz *et al.*, 2007). Most of the studies, which have used computerized attention training methods to train attention in children with ADHD, have addressed neuropsychological or behavioral observations. For example, in the Najafi *et al.,* (2006) study, only neuropsychological test was considered to evaluate attention and impulsivity. In the study carried out by Kurtz *et al.,* behavioral and academic evaluations were studied. This is while in the current study, we have addressed both neuropsychological and behavioral changes. On the other hand, to train children's attention in present study, novel tool was designed and tested. These are the advantage of the current study over many of the previously performed studies.

Based on the strong relationship between attention and learning performances, as well as considering the high prevalence of ADHD and resulted academic challenges, the present study aims at sustained attention training in children with ADHD using the attention training software, which is a software designed by the authors.

MATERIALS AND METHODS

This study included ADHD children in the age range of 9-11, referred to psychiatric and occupational therapy clinics in Tehran. Participants were diagnosed by a psychiatrist according to the criteria of DSM-IV, studying in the third to fifth grade in normal primary schools were included in the study. If the children with scores lower than 60 in the Conner's rating scale or IQ lower than 70according to the psychometrics, or any other accompanying psychiatric disorders or visual or audio problems were excluded from the study. The 18 participating children were randomly divided into two groups of case and control, each group with nine children. The participants were matched in terms of age, IQ, height, weight, and hours working with computer per day. The average ages of the case and control groupswere118.11 and 118.44 months, respectively.

Before and after the intervention, neuropsychological test and parents rating scale were used to investigate the changes after the intervention. In order to evaluate sustained attention, impulsivity rate, and participants' processing speed, the Persian version of Continuous Performance Test was used in a similar laboratory situation for all participants where was different from intervention setting. In the test, two numbers were appeared on the screen simultaneously. If the numbers were the same, the participant must press the answer key. Based on the answers, the number of omission and commission errors, and also mean reaction time were recorded. The commission error variable is the scale of measuring impulsivity; the omission error variable represents attention performance; and mean reaction time is the scale of measuring processing speed (Epstein *et al.,* 2003; McGee *et al.,* 2000).

The Conner's Parents Rating Scale was filled out by participants' parents one week before and after the intervention. In this study, revised form of the scale with48 items was applied, which included five subscales of learning problems, hyperactivity index, impulsivity-hyperactivity problems, conduct problems, anxiety problems, and psychosomatic problems (Khushabi *et al.*, 2006). Exclusion of teacher form of Conner's Rating Scale is one of the limitations through this study.

For the experiment group, ten 60-minutes sessions of working with Children's Attention Software, a new material, was planned; each three session were held in a week with one day rest between each session, and the intervention took 21 days to be performed. The place of the experiment was a 40-meter square room with proper air condition and light, and the least intervening audio stimulus.

The tasks in Children Attention Software were designed based on the tasks requiring sustained attention. They were approved and then validated by specialists. This software includes three tasks of shape-color, multiplying numbers, and story. Fulfillment of these tasks requires sustained attention. In the shape-color tasks, some slides including one or more 2×2cm square, circle, or triangle in yellow, red, blue, or green were appeared on a 15-inch screen. Whenever the yellow square appeared on the screen, the participant must press space key on the keyboard.

In each intervention session, the described task was carried out three times; each one took 5 minutes, and during completion of the task, there was a 2-3-minute break time. Stimulus show time, inter-stimulus interval, and stimulus show number were adjustable by the therapist. For the first three sessions, the slides included only one shape; in the next three sessions, two shapes were displayed, and in the following four sessions, each slide included three shapes.

Thus, the content difficulty was consistent with the increased number of stimulus. Moreover, in each session, slide show time and inter-stimulus interval were decreased 5 and 10 milliseconds, respectively; and considering the 5 minute presentation of the task box, 20 slides were added in each session.

In the task of multiplying the numbers, two numbers were displayed on the top and onion the bottom of the screen in each slide.

The participant must quickly multiply the two numbers in the top, and if the answer was equals to the bottom number, he/she should press the answer key. The task box numbers and rest time between each box was the same as the shape-color task. Stimulus show time, inter stimulus interval, and stimulus show number were adjustable by the therapist.

For the first three sessions, both numbers on the top of the screen were lower than five; in the next three sessions, one of the numbers was lower and the other one was higher than 5, and in the following four sessions, both numbers were higher than 5.

In each session, stimulus show time and inter stimulus interval were decreased 5 and 10 milliseconds, respectively. Therefore, in each session, 10 slides were added to stimulus numbers. In the two above-mentioned tasks, any correct or false answer received a proper audio feedback.

In the story task, after reading a story, the participant must answer three multiple-choice questions by keys 1 to 4 on the keyboard. The stories were selected from the story books published by "Children's Intellectual Development Association" according to the participants' age.

In each session, the participant should carefully read two stories, and then by pressing F5 on the keyboard, the story questions appear on the screen. After reading each story, there was a 2-3 minute break time. In order to increase the difficulty level of the task, in each session, the story text was about 20 words longer. Thus, each session included three packages of shape-color task, three packages of multiplying numbers, and two stories.

The control group was not involved in any intervention, and during the intervention, the participants were placed in the waiting list. After fulfillment of the intervention, the control group participants could attend the intervention program, if they were willing to and this was the main limitation present study.

The collected data was analyzed by SPSS software, version 11.5. Independent T test was applied to evaluate the similarity of demographic variables and other variables before intervention, and to determine the changes after intervention, as well. Paired T test was used to investigate the changes of each group, and independent T test was employed to evaluate treatment efficiency.

RESULTS AND DISCUSSION

Results

There was no significant difference before the intervention between groups in any of demographic, neuropsychological, and behavioral variables. Table 1 represents the mean value for demographic variables in two groups before and after the intervention, and Table 2 provides the mean value for behavioral and neuropsychological variables of two groups before and after intervention.

Table 1: Evaluating the similarity of demographic variables in two groups before intervention

Demographic data	**Experiment**	**Control**	**Evaluating two groups similarity (independent T test)**	
	mean ± SD	mean ± SD	T statistics	Level of significance
Age (month)	118.11±12.811	118.44±13.01	0.055	0.957
Height (cm)	136.89±7.322	133.22±5.518	1.2	0.248
Weight (kg)	34.22±10.109	32.78±4.206	0.396	0.698
Educational level	4.22±0.972	4.11±0.928	0.248	0.807
IQ	113.33±6.481	112.44±6.106	0.299	0.768
Working with computer (hour)	1±1.299	0.944±1.0138	0.101	0.921

Table 2: Mean value of behavioral and neuropsychological variables in the two groups before and after intervention.

Dependent variables	**experiment group**		**Control group**	
	Before intervention	**After intervention**	**Before intervention**	**After intervention**
	mean ± SD	mean ± SD	mean ± SD	mean ± SD
omission errors	13.44±4.773	5.56±4.216	13.33±4.899	14.44±3.127
commission errors	2.78±2.333	1.33±2.179	3.22±3.346	2.78±2.949
Mean reaction time	0.5321±0.0646	0.4631±0.0789	0.4989±0.0786	0.4991±0.0687
Learning problem	21.89±4.076	15.89±2.977	21.33±2.598	21.00±1.323
Hyperactivity index	27.00±3.937	23.11±2.848	25.33±3.317	25.56±3.844
Impulsivity-hyperactivity	9.78±2.949	8.22±2.167	10.89±1.537	10.22±1.787
conduct problem	13.67±5.148	12.78±4.684	12.67±4.359	13.00±4.243
anxiety problem	6.22±1.986	6.22±1.922	6.56±2.603	6.78±2.438
Psychosomatic problem	3.33±2.646	3.56±3.087	1.67±2.062	1.56±2.007
Total score of the Conner's scale	63.78±3.073	56.11±2.619	63.11±2.421	62.78±2.438

Moreover, before the intervention, the two groups were not significantly different in terms of any variables of continuous performance test and the Conner's rating scale.

The results of independent T test after intervention represented significant differences in some behavioral and neuropsychological variables.

The results of paired T test before and after intervention showed Significant difference in the numbers of commission error variable (P=0.021) and omission error variable (P=0.000).

Moreover, the value of mean reaction time decreased; however, the changes were not statistically significant (P=0.056) (Table 3).

In the experiment group, there was a significant difference in hyperactivity (P=0.000) and total score of the Conner's rating scale (P=0.000) after intervention. Moreover, there were changes in the variable of impulsivity-hyperactivity problems; but they were not statistically significant (P=0.054) (Table 4). No

positive change was observed in the neuropsychological and behavioral variables of the control group after the intervention.

Table 3: Evaluating neuropsychological variables before and after intervention in the experiment group

Dependent variable	T statistics	df	P-Value
Omission error	11.672	8	0.000
Commission error	2.871	8	0.021
Mean Reaction Time	2.229	8	0.056

Table 4: Evaluating behavioral variables before and after intervention in experiment group

Dependent variables	T statistics	df	P-Value
learning problem	4.213	8	0.003
Hyperactivity index	6.614	8	0.000
impulsivity- hyperactivity	2.256	8	0.054
conduct problem	1.955	8	0.086
anxiety problem	0.000	8	1.00
psychosomatic problem	-0.406	8	0.695
Total score of Conner's scale	9.390	8	0.000

Table 5: Evaluating intervention efficiency

Dependent variable	Mean difference	T statistics	df	P-Value
omission error	5.67	6.77	16	0.000
commission error	0.889	1.473	16	0.118
Mean reaction time	0.0219	2.953	16	0.009
Learning problem	4.56	3.320	16	0.004
Hyperactivity	2.78	4.181	16	0.001
Impulsivity- hyperactivity problem	1.33	2.790	16	0.013
Conduct problem	0.78	2.064	16	0.008
Anxiety problem	0.000	0.000	16	1.000
Psychosomatic problem	0.56	1.147	16	0.268
Conner's total scale	6.67	7.428	8.571	0.000

In order to investigate intervention efficiency in behavioral and neuropsychological variables, the difference between the values of the above-mentioned variables before and after intervention was Determined, and then the intervention efficiency was studied by independent T test. As shown instable 5, the children attention training software has represented its efficiency by leading to significant changes in numbers of omission error variable and mean reaction time in continuous performance test, and also the software had led to significant changes in learning problem subscales, hyperactivity index, impulsivity-hyperactivity problems, conduct problems, and total score of the Conner's rating scale. Although the control group did not receive any intervention in this study, the experiment group participants had considerable changes in mentioned variables.

Discussion

The present study results showed that the employed intervention had positive effects on attention performance by reducing impulsivity symptoms and decreasing learning, hyperactivity, and behavioral problems. The significant reduction in number of omission errors in neuropsychological scale indicates attention performance improvement in the case group participants. During the intervention, the stimulus appeared on the screen one after another. This matter provided the opportunity of involving working memory, one of the sustained attention elements (Warm *et al.*, 2008).

Therefore, positive changes can be explained from this point of view. In Najafi *et al.,* (2006), omission errors in the continuous performance test did not decrease in none of children participating in "learning how to type in a computer" group and "learning computer games" group. In fact, the results of the current study were not compatible with those of Najafi *et al.,* (2006), the differences in the two study results could be originated from not setting accurate difficulty rating in the Najafi *et al*.'s study (2006). On the other hand, in the study by Najafi *et al.,* (2006) the intervention took eight hours, while it took ten hours in the current study. Rapport *et al.,* (1996) performed comparative study between the efficiency of medical treatment with methylphenidate and attention training in ADHD children. The results showed that attention performance improvement is based on continuous performance test (Toplak *et al.*, 2008); our results are consistent with these findings. Sohlberg *et al.,* (2000) investigated the effect of attention training on the patients with brain damaged. They could not observe any considerable changes in performance of sustained attention network (Sohlberg and Mateer, 2001).

The difference between the results of the two studies could be explained by the difference in the samples investigated by Sohlberg *et al.,* (2000) and those of the present study. Kurtz *et al.,* (2001) used attention training method to show that attention performance in schizophrenic patients has been improved (Kurtz, *et al.,* 2007). Our results are compatible with their finding. Kurtz *et al.,* (2007) carried out another study on schizophrenic patients to show the improvement of attention performance and working memory (Kurtz *et al.*, 2007). Our results are in agreement with their results, as well. Moreover, several neural-based approaches studies were carried out, and showed attention performance improvement after neural-based interventions. For instance, euro-feedback interventions can be noticed. Thompson *et al.,* (1998) stated that inattentive symptoms have been decreased in ADHD children after 40 neuron- feedback sessions (Thompson and Thompson, 1998). Yaghubi *et al.,* (2008), as well, used continuous performance test to exhibit the decrease in the number of omission errors, which lead to decrease in inattentive symptoms (Yaghubi *et al.*, 2008). Changes of this variable were not significant in the control group. Since no intervention was carried out for this group, the result can be justified.

It was also showed that the number of commission errors variable in continuous performance test decreased significantly in the case group after intervention; this findings shows impulsivity decrease in the case group participants. Since the tasks applied in the intervention provide the chance for sufficient inhibition, and on the other hand, impulsivity is described as a reducer of inhibit oneself (Winstanley *et al.,* 2006), the changes in this variable are attributed to the practice and learning of how to inhibit oneself by the case group participants. Najafi *et al.,* (2006) demonstrated the reduction of number of commission errors in ADHD children in the "computer typing" group. The study results are in agreement with those of the present study. O'Connell *et al.,* (2006) also used cognitive therapy approach and sustained attention training method, and demonstrated reduction of impulsivity in ADHD children (Toplak *et al.,* 2008). The results of our study are also compatible with that of O'Connell *et al.,* (2006) in the case group, mean reaction time had positive changes after the intervention, but the changes were not statistically significant. It should be noted that mean reaction time is a scale to measure the processing speed (Epstein *et al.*, 2003; McGee *et al.*, 2000).

Investigations imply that computerized interventions lead to a decrease in the mean reaction time and thus increase in the processing speed (Najafi *et al.,* 2006). Regarding the positive changes of the variable, more sessions might be needed for the variable to show statistically-significant changes. Najafi *et al.,* (2006) reported similar results in children with ADHD. White *et al.,* (2006) study results demonstrated decrease of mean reaction time after a two-session alternative attention training program. Invaded adults; which is not in agreement with those of the current study. The difference between the results could be explained by the difference in the method of measuring alternative attention. In the above-mentioned study, the scale of measuring alternative attention was the mean reaction time of carrying out the interventions at the beginning of each session. In another study carried out using euro-feedback interventions, the mean reaction time was reduced in ADHD children (Thompson & Thompson, 1998; Yaghubi *et al.,* 2008). Anyway, this reduction level of mentioned variable could possibly be attributed to extraneous influence.

In the parents' form of the Conner's rating scale, significant changes were observed in the scores of subscales such as learning problems, hyperactivity index, and total score of the Conner's rating scale. Furthermore, score of impulsivity-hyperactivity problem has been changed in a positive direction.

Learning problems subscale consists of questions about general attention and duration of on-task behaviors of children. The significant changes in the score of learning problems could be explained by the relation between attention performances and learning (Wickens and McCarley, 2008). Kerns *et al.,* (1999) showed significant improvement in the academic scales after attention training in children with ADHD; their results support the findings of the current study. However, Williams (1989) reported some contrary results (Kerns *et al.,* 1999). Shalev *et al.,* (2007), school books were used, to investigate the effect of attention training on participants' academic performance. After the study, significant improvement was reported in both "copying text" scale and "comprehension" scale. In other words, improvement in these scales implies improvement in learning functions, which is consistent with our findings. After the intervention in control group, no considerable change was observed in this subscale score.

After the intervention, hyperactivity index score was considerably decreased. It should be considered that off-task behavior is the main reason leading to a decrease in academic performance of ADHD children (Vile *et al.,* 2006). It is a noteworthy point that hyperactivity and restlessness during in the class are described as off-task behaviors. Therefore, the decrease of hyperactivity index score could be resulted from decrease of off-task behaviors. Cameron and Robinson (1980) showed increase of involvement in class activities in ADHD children by using cognitive therapy method (Cameron and Robinson, 1980) that is consistent with our findings. Kerns *et al.,* (1999) carried out an attention training program, but no significant changes was observed in the hyperactivity index related to ADHD Behavior Measuring Scale, which is different from the findings of the current study. The difference between the results of the two studies originates from the difference between the tools employed to record behavioral observations from the parents' viewpoint. In another study carried out by Shalev *et al.,* (2007), it was demonstrated that computerized intervention affected children attention performance, and hyperactivity symptoms were decreased, which is similar to our results.

The total score of the Conner's rating scale significantly decreased after the intervention. Since the total score is obtained from the sum of scores of the subscales, the decrease in the total score of rating scale is caused by the decrease in the subscales scores. Kliengberg *et al.,* (2005), behavior symptoms decreased in ADHD children. Their study was based upon the Conner's parents' rating scale; and was performed in25 days to train working memory. Our results are compatible with their findings (Klingberg *et al*., 2005).

The subscale of impulsivity-hyperactivity problems showed significant positive changes in the experiment group; the levels of changes are measured before and after intervention. Etiological hypothesis have considered deficit in response inhibition, alternation or timings the underlying causes of the problem (Williams and Dayan, 2005). As mentioned before, hyperactivity index score decreased in our study. So, the changes in impulsivity-hyperactivity subscale after intervention might originate from the relationship between impulsivity symptoms and hyperactivity symptoms; since in DSM-IV these two groups of symptom are mentioned simultaneously (Najafi *et al*., 2006). However, the insignificant of the changes could be attributed to unknown external factors.

After the intervention, no considerable change was observed in behavior, anxiety, and psychosomatic problem subscales in the case group participants. It was assumed that an increase in the involvement in the activities and observation of the rules of each task, the conduct problem score is decreased. No changes in the score of conduct problem subscale were seen. Although no research was found about the effect of attention interventions on decrease of conduct problems, Linden *et al.,* (1996), Toplak *et al.*, (2008) and Yaghubi *et al.,* (2008) as well carried out studies that showed decrease in the behavioral problems after neuron-feedback intervention.

The relationships between attention performances and anxiety symptoms (Amir *et al.*, 2009; Eysenck, 1988; Fox, 1993), and also the decrease in the performance of anterior cingulated areas and pre-frontal cortex in anxiety (Bishop *et al.*, 2004) have been proved in many different studies. Considering the importance of these areas in attention performances, it was assumed that by training attention

performances, anxiety symptoms would be decreased. In Amir *et al.'s* study (2009), the results indicate that after attention training, anxiety symptoms were decreased in individuals with anxiety disorder. Wells *et al.,* (1999) demonstrated that after attention training program, improvement in stress symptoms were observed in patients with attention disorders (Wells *et al.*, 1997); which is similar to current study. Some researchers have been aimed at evaluation of the effect of attention training on anxiety symptoms; these studies have used selective attention training. In the current study, the insignificant change in the scores of this subscale is probably because of particular aiming at sustained attention performance.

After intervention, no changes were observed in the score of psychosomatic subscale. It was assumed that considering the relationship between attention and anxiety, and also the close relationship between anxiety and psychosomatic symptoms (Haug *et al.*, 2004; Wientjes and Grossman, 1994), attention training probably leads to a decrease in the psychosomatic symptoms in the case group. The only study found about the effect of attention training on psychosomatic problems was the study carried out by Yaghubi *et al.,* (2008), in which after 30 neuron-feedback sessions, the psychosomatic problems of children with ADHD decreased. Experiencing transient pain by the child may be considered as a psychosomatic symptom by parents; which would affect the score of this subscale in the Conner's rating scale. Changes in studied variables in experiment group participants could be attributed to the efficiency of children attention training software. Thus, the software is shown to be effective as it led to a decrease in the scores of the above-mentioned variables. As a result, the intervention can be considered as an efficient method in decreasing some symptoms of the disorder.

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