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The Effect of Rehabilitation Games on Sustained Attention in University Students: A Randomized Clinical Trial

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Original Article

Abstract

Introduction: Filial therapy is an effective strategy dealing with cognitive disorders. The aim of this study is to investigate the impact of rehabilitation computer games on increasing sustained attention in university students.

Materials and Methods: In this randomized clinical trial, the target population consisted of students in Islamic Art University of Tabriz, Iran, in 2019 among who 30 students were selected with convenience sampling and divided randomly into two groups of 15 each by lot. 15 subjects played the rehabilitation games and the remaining 15 ones in the control received no intervention. The data were analyzed by multivariate analysis of covariance (ANCOVA).

Results: Data analysis showed that there was a significant difference between the pre-test and post-test scores of the experimental and control groups ($P < 0.04$), indicating that the rehabilitation game has improved the level of attention ($P \leq 0.02$).

Conclusion: This study shows that rehabilitation games can be used as an effective method in individuals to increase attention.

Keywords: Rehabilitation; Attention; Computer games

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Introduction

Attention refers to a series of complex mental operations that include focusing or engaging in a goal, holding or enduring and listening for long periods of time, coding stimulus characteristics, and shifting focus from one goal to another (1). In fact, attention is one of the cognitive functions that can be enhanced by cognitive rehabilitation (2). Recognizing the components of attention is problematic in several ways; Attention is often assessed in relation to some other activities and is difficult to measure (2). On the other hand, neuroscientists believe that attention is the result of the interaction of different areas of the brain and there is no specialized area in the brain that is solely responsible for the attention functions (1-3). Neuropsychological classification, however, considers the components of attention to include the regulation of arousal and care, selective attention, sustained attention, breadth of attention or split attention, deterrence, and behavior control (4). There is a limited information processing capacity in the brain (2) and therefore, active participation of individuals in one or more tasks at the same time is difficult. Among these, the main challenge in adapting to large volumes of information occurs when a particular function requires the implementation of both high-level skills and a large amount of information.

In recent decades, there has been a growing interest in the use of computers in the field of cognitive problems with the aim of treating developmental disorders, leading to the expansion of computer-based cognitive training programs (5). Cognitive empowerment or training refers to training

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based on cognitive science findings that in the form of games (mainly computer games), tries to improve cognitive functions including precision, attention, visual-spatial perception, hearing discrimination, types of memory, especially working memory (WM), and other executive functions (6). All of this points to the principle of neuroplasticity (7). Cognitive rehabilitation is the result of the integration of neuroscience with information technologies (IT) (2) and is used to enhance the brain capabilities in cognitive functions such as perception, attention, soberness, memory, etc. (8).

One of the problems of children with various learning disabilities is their low motivation to do their homework and learn. It seems that using a computer and teaching a child through computer games can help to solve this problem to a great extent (8). Attention deficit is one of the cases that is not only specific to childhood and school and its symptoms and cases are often persistent and cause problems in one or more areas such as school, home, university, workplace, etc. (7). Thus, it is important to address this issue. Various educational programs have been developed to improve these functions the effectiveness of which has been confirmed in various studies (9). Cognitive education and rehabilitation, by involving and applying a set of cognitive abilities of individuals, improves and increases these abilities in them (2). One of the methods through which neuropsychological rehabilitation can be used is the use of computer software and games appropriate to these abilities. This treatment has the advantage over other methods, especially medication, that it has no side effects (10). The aim of this study is to investigate the effect of rehabilitation games on sustained focus and attention using computer games.

Materials and Methods

This was a preliminary, causal-comparative study with a controlled clinical trial design. The statistical population of the study included the students of Tabriz Islamic Art University, Tabriz, Iran in the academic year of 2019-2020. At first, those who were willing to participate in the study were specified by a call and those who met the inclusion criteria were selected. The main inclusion criteria were no defined history of mental illness or diagnosed cognitive disorder. Accordingly, 30 volunteers were included in the study by the convenience sampling method and were randomly divided into two groups of control and experiment each with 15 subjects. First, the details of the project were provided to the participants and after signing the consent form, they entered the study. The subjects were informed that they could leave the study at any stage they felt unable to continue collaboration with the study after arranging with the researchers. In the next stage, the performance level of the two groups was evaluated and then the experimental group received 20 sessions of rehabilitation games, however no intervention was performed in the control group. Finally, the sustained attention performance level of the two groups was assessed again. The data collection tools were as follows.

Software-based neuropsychological rehabilitation: included training provided to the experimental group by the SoundSmart educational software (Windows, Version 1. BrainTrain Inc., Chesterfield, USA). SoundSmart is an attractive educational program designed like a computer game. This program consists of 11 games with different levels and in addition to teaching and practicing the alphabetic letters, improves attention and WM skills, listening skills, spelling and pronunciation of letters, distinguishing and discriminating sounds, mathematics courses of the first to fifth grades, following instructions, brain processing speed, and even impulse control (skills necessary for success in life and education) (8). This program, which is one of the mental education programs, was launched by the BrainTrain Inc. in the United States. The SoundSmart program has unique effects on children's cognitive and learning abilities, especially in the school and preschool ages (2). The aim of the present study is to examine the level of attention management, which includes the tasks of basic auditory processing, letter recognition, color recognition, instant auditory memory, auditory attention, rapid visual review, tolerance and restraint, faster processing speed, recognition of small and capital letters, and following simple single-stage commands (10). In order to make this method operational, the SoundSmart software was taught to each member of the experimental group in 20 sessions of 30 to 45 minutes [twice a week (Saturday and Tuesday every week)]; In this way, in the first session, the work procedure and its steps were explained to the students and a training step for each student to get acquainted with the computer and software space, and then 19 training sessions were presented to each of the participants.

Continuous performance test: This test was made by Farmed Tajhiz LTD. (Tehran, Iran) in which the subjects are faced with a series of consecutive stimuli in a certain period of time whose task is to provide a response to the perception of the target stimulus and to find disorders in the sustained attention deficit (2). In this test, a series of numbers with a fixed time interval and two stimuli are determined as the target stimuli. The participant must press the relevant key on the computer screen as soon as possible after seeing the desired numbers. The variables

measured in this test include deletion error (not pressing the target key against the stimulus), committing error (pressing the key against the non-target stimulus), and reaction time (average reaction time of correct responses to the stimulus in thousandths of a second) (6). Hadianfard et al. reported the reliability of this test through retesting for different parts in the range of 0.59 to 0.93, which was significant at the level of 0.01. Additionally, they reported a good validity for this test through criterion-related validity (11).

The normal distribution of variables was assessed using the Shapiro-Wilk test. The data obtained were analyzed using descriptive statistics [mean and standard deviation (SD)] and inferential statistics. The intra-group and inter-group comparisons were analyzed using multivariate analysis of covariance (MANCOVA) test in SPSS software (version 21, IBM Corporation, Armonk, NY, USA). $P < 0.05$ was considered as the significant level. The test power was also determined by the Eta squared method.

Results

During the study, there was no drop in the participants of the two groups and therefore no intention-to-treat (ITT) analysis was performed. The demographic characteristics of the study samples are presented in table 1. Based on this table, there is no significant difference in the demographic characteristics between the two groups.

The data in table 2 shows no significant difference in the variables between the groups in the pre-test stage.

Before using the MANCOVA test for the study variables, the assumption of homogeneity of variance was examined using the Levene's test, which was not significant for none of the variables of the two groups. Moreover, Box test was employed to test the assumption of homogeneity of covariance, with the results showing that the difference in covariance was not significant ($F = 1.21$, $P \leq 0.05$). As a result, the assumption of homogeneity of covariance was true and the covariance analysis assumptions were confirmed. Based on the data presented in table 3, the significance levels of all tests allowed the use of the MANCOVA test. These results indicated that there was a significant difference between the two groups.

Based on the data in table 4, the rehabilitation game significantly improved attention in the experimental group.

Discussion

Neuroscientists believe that attention is the result of the interaction of different areas of the brain, and that there is no specific area in the brain that is solely responsible for attention functions, but different types of attention use the same parts of the brain (12). In the present study, the effect of a cognitive rehabilitatin game on the sustained attention in healthy young subjects was investigated and it was found that engaging in this game in the short term leads to a significant improvement in the sustained attention. Finally, the results of the present study were in agreement with the findings of the studies by Garcia-Redondo et al. (13), Rajabi et al. (14), Ponce et al. (15), Yang et al. (16), Nadartbar et al. (17) and Jangi (18) as computer games can improve attention.

One of the common theories in recent decades in explaining learning disorders is cognitive and neuropsychological theories. The pioneers of cognitive approaches in explaining learning disorders derive their ideas mainly from prominent psychologists of the cognitive approach, the most prominent of whom is Buchan (19). The most important assumption in the cognitive approaches is that successful learners actively make sense of their previous experience and thought processes about new information (14). They use executive or metacognitive processes or functions to determine how new information is searched, perceived, related to the previously stored information, and selected and recalled. According to this approach, what distinguishes between a skilled and an unskilled learner is the inability of the unskilled learner to use the executive processes effectively (15). Regarding the explanation of learning disabilities, various theories such as genetic, biological, developmental, cognitive, behavioral, and educational theories have been proposed, each of which focusing on and explaining a specific aspect of this disorder (20,21).

In the neuropsychological rehabilitation program, the difficulty level of the tasks is determined based on the individual's initial readiness level and this level increases gradually based on his progress, besides, the game time is not long and does not make the individual tired and helps him raise his attention and maintain it (22).

Table 1. Demographic characteristics of the participants

Group	n	Age (year) (mean ± SD)	Gender [n (%)]		Level of education [n (%)]	
			Male	Female	BSc	MSc
Experiment	15	24.00 ± 1.09	5 (33.3)	10 (66.7)	10 (66.7)	5 (33.3)
Control	15	24.06 ± 1.26	6 (40.0)	9 (60.0)	9 (60.0)	6 (40.0)
P value (Intergroup)		0.53	0.71		0.69	

Table 2. Attention score (continuous performance test) of the experimental and control groups in the pre-test and post-test stages

Component	Group	Pre-test	Post-test	P value (Intra-group)
False announcement error	Experiment	10.10 ± 1.37	4.00 ± 1.81	0.02
	Control	10.90 ± 1.91	9.80 ± 2.44	
	P value (Intergroup)	0.03	0.04	0.04
Deletion response error	Experiment	8.82 ± 2.09	3.30 ± 1.41	0.02
	Control	7.70 ± 1.56	7.20 ± 1.87	
	P value (Intergroup)	0.02	0.01	0.03

Data are reported based on mean ± standard deviation (SD).

Table 3. Results of multivariate analysis of covariance (MANCOVA) test of the experimental and control groups in the post-test stage of attention test (continuous performance test)

Test	Value	F	P value
Pillai's trace	0.630	5.70	0.001
Wilks' lambda	0.397	7.04	0.001
Hotelling's trace	1.450	8.33	0.001
Roy's largest root	1.400	17.51	0.001

In general, based on the brain plasticity hypothesis, it can be explained that the possible effects of this software are due to the cognitive exercises and their repetition. In other words, it is assumed that the same mechanism underlying the experience-dependent plasticity processes (2) produces spontaneous or guided improvements (through rehabilitation) in these disorders. Repeated and guided cognitive training (such as cognitive rehabilitation) causes structural and functional changes in the neurons responsible for these actions in the brain; changes that can be sustainable according to the human brain plasticity and self-healing hypothesis (8).

Limitations

One of the biggest limitations of the present study was the small number of participants in the test. Besides, these subjects were all university students in the field of art and were not a good sample of people in the community.

Recommendations

It is suggested that future studies use a neuropsychological rehabilitation program for other neurodevelopmental disorders. It is also recommended that by acquiring knowledge in the field of game development, a native game be researched and produced with the aim of influencing attention, especially sustained attention. Cognitive training designed for executive actions is likely to provide lasting improvement in children with learning disabilities. Further investigation seems necessary to elucidate this hypothesis in the future.

Conclusion

The results of the present study showed that cognitive rehabilitation game can be applied as an effective method to increase sustained attention in individuals.

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Table 4. Results of multivariate analysis of covariance (MANCOVA) test with the aim of determining the difference between the two groups in sustained attention

Distribution source	Dependent variable	Sum of squares	Degrees of freedom	Mean of squares	F	P value
Group	False announcement error	39.14	2	19.57	25.75	0.001
	Delete response error	10.92	2	5.46	11.45	0.001

Authors' Contribution

Yazdan Movahedi: Study design and ideation, supportive, executive, and scientific study services, providing study equipment and samples, analysis and interpretation of results, specialized statistical services, manuscript preparation, specialized evaluation of the manuscript in terms of scientific concepts, approval of the final manuscript to be submitted to the journal office, the responsibility of maintaining the integrity of the study process from the beginning to the publication, and responding to the referees' comments; Ali Mousivand: supportive, executive, and scientific study services, providing study equipment and samples, data collection, analysis and interpretation of results, specialized statistical services, manuscript preparation, specialized evaluation of the manuscript in terms of scientific concepts, approval of the final manuscript to be submitted to the journal office, the responsibility of maintaining the integrity of the study process from the beginning to the publication, and responding to the referees' comments; Mahdi Pourjafar: supportive, executive, and scientific study services, providing study equipment and samples, data collection, analysis and interpretation of results, specialized statistical services, manuscript preparation, specialized evaluation of the manuscript in terms of scientific concepts, approval of the final manuscript to be submitted to the journal office, the responsibility of maintaining the integrity of the study process from the beginning to the publication, and responding to the referees' comments.

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Conflict of Interest

The authors declare no conflict of interest.

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