DOI: 10.22122/jrrs.v15i1.3445 Published by Vesnu Publications

Dynamic Difficulty Adjustment of a Cognitive Game Based on Neurofeedback in Order to Help Treat Attention Deficit Hyperactivity Disorder

Mina Masoudi[1], Javad Rasti[2], Amin Mahnam[3], Ahmad Abedi[4], Mohammad Ali Nazari[5]

Original Article

Abstract

Introduction: Attention deficit hyperactivity disorder (ADHD) is one of the most prevalent neurological disorders among the children and adolescents. Neurofeedback-based exercises, as a new method in non-pharmacological treatments, can help to improve their performance by modifying existing abnormalities in some of the brain frequency bands of these children. The aim of the present study was to develop and design a computer game as a platform for neurofeedback exercises by employing dynamic difficulty adjustment in the game design.

Materials and Methods: This study was carried out to evaluate the dynamic difficulty setting in the game and measuring the satisfaction of play with dynamic difficulty versus static difficulty in 4 sessions on 6 participants of 20 to 26 years. They graded their experience in each session from 1-10 depending on the amount of enjoyment. Then, 2 boys of 12 and 13 years with ADHD participated by playing the game for 10 sessions.

Results: There was a significant difference between the participants' satisfaction with dynamic difficulty versus static difficulty ($P = 0.002$). Moreover, the game had a positive impact on improving brain function in children with ADHD.

Conclusion: The results showed that children were attracted and motivated to use the game for treatment. Adjusting the challenges based on the individual skills maintained the user's motivation from the beginning to the end of the game, and enhanced user's enjoyment and motivation to continue the therapy.

Keywords: Attention deficit hyperactivity disorder (ADHD), Computer games, Neurofeedback, Dynamic difficulty adjustment (DDA)

Citation: Masoudi M, Rasti J, Mahnam A, Abedi A, Nazari MA. **Dynamic Difficulty Adjustment of a Cognitive Game Based on Neurofeedback in Order to Help Treat Attention Deficit Hyperactivity Disorder.** J Res Rehabil Sci 2019; 15(1): 28-35.

Received: 27.01.2019 Accepted: 01.03.2019 Published: 04.04.2019

Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the most common neurological disorders with impaired executive skills in childhood (1). According to global studies, the average prevalence rate of ADHD in society is 3 to 5% of all school-age children, being higher for boys compared to girls (2). Among the most obvious symptoms of this disorder are attention deficit, hyperactivity, and impulsivity, which are due to the impaired executive function (1). Additionally, most of these children have motivational problems due to impairments in the dopamine transporter (3). Dopamine is an organic compound in the brain that acts as a neurotransmitter, and drugs used for these children play a stimulating role in the release of this neurotransmitter (4). Therefore, children with ADHD are exposed to a variety of problems such as poor educational performance, anxiety and depression, and problems in social relationships in adulthood (5).

Besides, the results of studies have shown that the prefrontal cortex (PFC) and its adjacent systems play a

1- Department of Biomedical Engineering, School of Engineering, University of Isfahan, Isfahan, Iran
2- Assistant Professor, Department of Biomedical Engineering, School of Engineering, University of Isfahan, Isfahan, Iran
3- Associate Professor, Department of Biomedical Engineering, School of Engineering, University of Isfahan, Isfahan, Iran
4- Associate Professor, Department of Psychology of Children with Special Needs, School of Education and Psychology, University of Isfahan, Isfahan, Iran
5- Associate Professor, Department of Cognitive Neuroscience, School of Educational Sciences and psychology, University of Tabriz, Tabriz, Iran
Corresponding Author: Javad Rasti; Assistant Professor, Department of Biomedical Engineering, School of Engineering, University of Isfahan, Isfahan, Iran; Email: rasti@eng.ui.ac.ir

relatively prominent role in the relationship between the brain structure and executive functions (1). Moreover, several studies have concluded that individuals with this disorder have electrical signals different from those of their peers (5-9). Therefore, a treatment should be considered for them that can change their brain waves and bring them closer to the normal conditions. This is performed using neurofeedback. Neurofeedback is a learning process using computer technology that aims to teach the brain self-regulation and tries to teach the brain how to regulate itself (10).

Neurofeedback training is a non-pharmacological treatment without side effects and one of the most effective treatments for ADHD, the therapeutic effect of which can continue for up to six months after treatment (11). Neurofeedback exercises can be effective when performed for at least 20 to 30 sessions and at least 20 to 30 minutes per session (12). Due to the length of the treatment sessions and the presence of motivational problems in children with ADHD, the child may not be interested in neurofeedback and may avoid treatment. Since computer games are among the popular entertainment tools for children and adolescents and have the ability to increase the individuals' interaction with educational programs, are useful tools to complete the treatment process (13).

Although technology is constantly evolving in computer games, there is a dissatisfaction from users, which is due to the limited level of challenge that is offered to them (14). Users expect to be offered a level of challenge that is consistent with the individuals' characteristics; because for high-skilled users, an easy game may be boring, and for the low-skilled users, a difficult game may be frustrating (14,15). In order to manage the player's experience during the game and to match the level of individual skills with the level of challenges in the game, numerous studies have been accomplished in recent years (14-18). Dynamic difficulty adjustment (DDA) is a process in which the parameters, game features, scenarios, and behaviors change automatically, which can be based on the individual's performance in the game or on the basis of a physiological signal (14). According to studies, an adaptable DDA mechanism should consider different aspects and not be based on a specific condition. The goal of using this mechanism is to maintain the user's interest and motivation from the beginning to the end of the game and to provide a suitable level of challenges in the game (18-20).

The present study is conducted with the objective to design a game based on neural feedback. Due to the boring nature of neurofeedback therapy sessions, the need to repeat sessions to stabilize it in the long run, as well as the motivational problems of children with ADHD, the DDA system was employed in the game design to create and maintain motivation. With the use of DDA, children's motivation to participate in treatment is expected to be maintained from the beginning to the end of treatment.

Materials and Methods

The first challenge in this study was to design and develop a computer game, and the next challenge was to use the parameter extracted from the brain signal in accordance with the treatment pattern of children with ADHD in the game design. At the same time, the most important challenge was to use the DDA mechanism in the game development.

The game designed in the present study was a two-dimensional runner style and only one key was used as the controller in the game. This game runs on a computer or laptop. In the game environment, different platforms located at different distances and at different heights were used. These platforms were of different sizes, and on some of them there were enemies that were in two different models; with the first model of enemies moving on the platform and the second model shooting arrows. This was the initial design and fun part of the game.

The user had to jump from different platforms without hitting the enemies using the Space key. The number of jumps intended for the character was two, and in fact, the jump in this game was defined as double jumping. Furthermore, to increase patience and the ability to expect in children, coins are produced at a far distance from the game's character, and the user cannot easily obtain them at the beginning, and over time, he needs iron shoes or jet pack. Therefore, it is necessary for the user to wait to get the shoes and the jet pack.

Another clinical feature of children with ADHD is the lack of motivation. Therefore, in order to maintain and increase their motivation, the game was divided into four parts, with a different backstage in each part (Figure 1). Between the parts of the game, the user entered a store that could buy the existing prizes with the coins he had collected during the game.

Figure 1. Various backstages designed in the game

Another clinical feature of children with ADHD is their impatience and tendency to respond immediately to their needs (1). In order to cover this problem in the game, a store was considered that included prizes. A certain amount of time was required for the user to continue playing until the end of this time without losing the game to reach the store and buy prizes using the coins he had collected on his way, and then move on to the next section. This required patience and effort.

Application of neurofeedback in the game: Neurofeedback-based computer games require a parameter extracted from the brain signal to be used in the game. According to studies and after examining the effectiveness of different treatment patterns at the behavioral and neurological levels, it was found that the therapeutic pattern of reducing the theta/beta power ratio led to the reduced behavioral problems and improvement in executive functions (6-8,21,22). Furthermore, Lubar et al. in a study found that the best points for evaluating this index were the central points on the middle belt of the skull, the FZ, CZ, and PZ points (6). Therefore, this parameter, extracted from the brain signal appropriate to the treatment pattern, was used in children with ADHD to e integrated in the game.

The neurofeedback provided in the present study was to give the person the ability to move the game forward more easily and quickly. These features were considered in three separate modes: "armor or shield, iron shoe, and jet pack".

Having a shield created a yellow halo around the character which could hit the enemies without compromising the health of the game's character (Figure 2.a).

With shoes, the character could perform larger jumps and could easily cross a wide gap if any. In addition, the shoed had a magnetic property that allowed it to attract the coins in the sky (Figure 2.b).

If the person had a jetpack, the game character could fly. In this case, the user could move the game character up and down in the sky using the up button (↑) or down button (↓) on the keyboard and get the coins that are placed there (Figure 2.c).

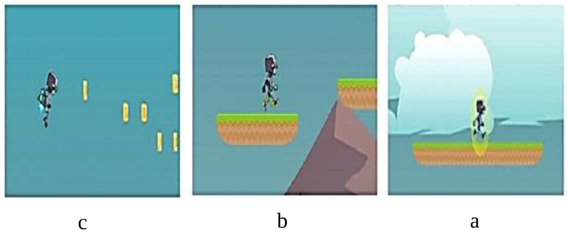

Figure 2. Various features offered in the game, including shield (a), shoes (b), and jetpack (c)

The important point considered in the present study was that it was not enough to just enhance the brain signal to the desired state and the user had to maintain his brain state in that desired state. This was implemented in the features provided for the character; In this way, if the user could keep his brain in the desired state for 1 second, he got a shield, if he held it for 3 seconds, he gained shoes, and if he could maintain the maximum desired level (5 seconds), he gained a jet pack. These three items remained temporarily for the character, and after the time considered for each of them elapsed, the game character lost them. The goal of this design was to train the player keep his attention in a desired level. Due to the use of the therapeutic model, the optimal state of the brain signal in the present study was to reduce the theta/beta ratio from the threshold level considered in the game. According to the usual neurofeedback-based treatment protocols with commercial systems, this threshold was considered to be 80% of the average theta/beta ratio in the previous 30-second period. This threshold was updated every 30 seconds. Therefore, a dynamic threshold was set.

Application of DDA in the game: The DDA mechanism in the game was designed in such a way that the user's performance and mental state during the game led to a change in some of the game parameters. The overall DDA block diagram in the game is demonstrated in figure 3.

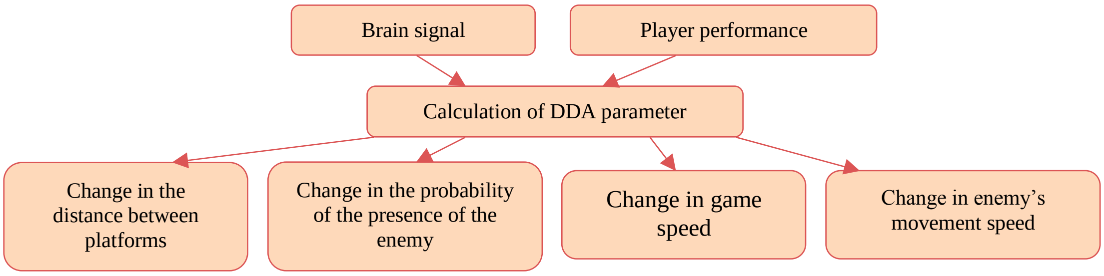

Figure 3. Dynamic difficulty adjustment (DDA) block diagram

In order to evaluate the user's performance at any time, the time spent by the user relative to the total game time and the user's health rate at that time relative to the total health rate considered in the game were calculated. Obviously, the longer and healthier the user remained, the better his performance was. The user's mental state was also determined based on the theta/beta ratio extracted from his brain signal.

After normalization, the parameters were summed up and placed in a variable called DDA, which resulted in a value between zero and 1 due to the normalization of the parameters and then the normalization of the variable itself. In this game, three levels of difficulty were considered and one of these three levels was selected based on the value of the DDA parameter. Based on each level, the distance between the platforms, the probability of the presence of enemies, the speed of movement of enemies, and the speed of play were determined.

To evaluate the DDA design in the game, another version of the game, which was quite similar to the first version, was developed, with the only difference that the difficulty of the game did not change during the game and was considered static. In this case, difficulty level 2 was set by default in the game and remained at the same level from beginning to end and did not change.

Participants: The present study protocol, numbered IR.UI.REC.1396.021, was approved by the Ethics Committee, University of Isfahan, Isfahan, Iran and registered on the Iranian Registry of Clinical Trials (IRCT) with the clinical trial code IRCT20200306046705N11. After a brief explanation of the objective and process of the study for the individuals and parents of the children with ADHD, the study consent form was completed and signed by them.

The participants consisted of two groups, with the first group consisting of 4 girls and 2 boys aged 20 to 26 years. This group participated in the study in order to evaluate the level of satisfaction and pleasure of the dynamic game compared to the static game. Then another group was considered to evaluate the effectiveness of the study on children with ADHD. The subjects in the second group consisted of 8- to 13-year-old students who were referred to the Center for Learning Disabilities (Counseling Center, Education Department, District 3, Isfahan) due to poor educational performance, lack of concentration, and hyperactivity at school. The children were then referred to a child psychiatrist at the same center and were clinically confirmed to have ADHD. Due to the limitations in finding children with ADHD, the current study was carried out on only two 12- and 13-year-old boys with ADHD. Figure 4 illustrates a child with ADHD during testing and when receiving a prize from the game store.

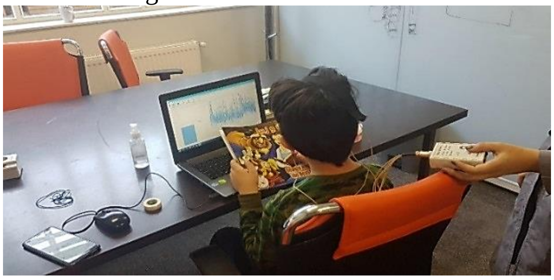

Figure 4. Participant with attention deficit hyperactivity disorder (ADHD) when receiving a prize from the game store

Recording brain signal and determining base line: In order to investigate the theta/beta parameter in the present study, a two-channel recording system (Rayan Mind Ware Company, Iran), only one channel of which was used, was extracted (23). The device and its specifications are shown in figure 5.a and 5.b, respectively. The positive electrode was connected to the skull in the CZ area according to the standard 10-20, the negative electrode was connected to the left ear, and the right-leg drive electrode was connected to the right ear (24). At the beginning of each session, the base line of the participant's brain signal was obtained for 90 seconds and was considered as the initial threshold level. In addition, at the end of the game, the base line was taken from the person for 90 seconds to check the short-term effect of the game.

(a)

Developer	Rayan Mind Ware Company
Number of channels	2
Data transfer	Via Bluetooth (Wireless)
Sampling rate	250 samples per second
Supply	Rechargeable lithium-ion battery
Dimensions	5 * 8.5 cm^2
Analogue to digital converter resolution	-4.2 ~ +4.2
Input short-circuit noise	4uV
Placement	Installable on clothes

(b)

Figure 5. a. Recording system, b. its specification table

To assess the differences between the dynamic and static difficulty, the scores of the participants were entered in SPSS software (version 16, SPSS Inc., Chicago, IL, USA) in the two separate groups of dynamic difficulty and static difficulty. Given the normal distribution of the data was determined and confirmed using the Q-Q plot, the independent t-test was employed to test the significance of the difference between the two versions of the game.

Results

Evaluation of the game dynamic difficulty in the adult group: Before the start and after the end of the game, in the neurofeedback sessions, a baseline signal was taken from the participants for 90 seconds. After playing in each session, the group scored the game between 1 and 10 points, depending on their level of satisfaction and enjoyment of the game. The values of the baseline before and after the game, as well as the score of the participants in all four sessions, are presented in table 1.

The results of this experiment are reported in table 2 as the sum and mean of the scores in each version of the game.

Table 2. Survey results in the first group of participants

Play with	n	Total score	Mean
Dynamic difficulty	12	106.6	8.875 ±0.801
static difficulty	12	91.5	7.625 ±0.932

As it can be observed, the participants gave higher scores to the game with dynamic difficulty. Based on the results of the independent t-test, there was a significant difference between the two groups ($P \leq 0.002$).

Evaluation of the effectiveness of play in the children group: In the children group, before and after the play, a baseline signal was taken from the participants for 90 seconds, the value of which in 10 sessions for the two subjects is given separately in figure 6.

As figure 6, in most cases the baseline at the end of the sessions was less than that at the beginning of the sessions.

Discussion

Problems observed in children with ADHD are associated with the impaired executive functions. On the other hand, investigation of the electroencephalography (EEG) signals of these children shows many changes compared to normal children, such as an increase in the theta band activity and a decrease in the alpha and beta band activity. Therefore, neurofeedback training with modification of the abnormal brain signals can be considered as one of the best treatment options for these children; Because it specifically affects brain function. The optimal effect of this treatment relies on the long-term follow-up of the courses of treatment. Therefore, maintaining motivation during treatment is of great importance. Computer games are a suitable platform for implementing the neurofeedback-based exercises, as they are one of the most popular entertainment tools for children.

The aim in this study was to design a game based on neurofeedback, which due to the long duration of treatment, DDA, which is a motivating mechanism in the game design, was employed to maintain and increase children's motivation in the game development. In addition to improving the brain function of children with ADHD, the game was expected to improve children's clinical behaviors, including increasing patience and constant attention, and given consistency of the difficulty level of the game with the players' performance, the participants enjoyed the play process.

Table 1. Baseline values at the beginning and end of the game and scores given to each participant in each game

Number of participants	Play with dynamic difficulty			Play with static difficulty		
	Base line before the game	Base line after the game	Score	Base line before the game	Base line after the game	Score
1	1.087	1.012	7.5	1.025	0.762	8.0
1	1.062	0.475	9.0	0.962	0.900	8.5
2	0.950	0.712	8.5	1.012	1.125	7.5
2	0.937	0.787	9.0	0.887	0.850	6.5
3	0.612	0.262	7.5	0.562	0.525	6.5
3	0.587	0.475	9.0	0.725	0.687	8.0
4	0.400	0.275	10.0	0.950	0.775	8.0
4	0.725	0.625	8.5	0.750	0.700	9.0
5	0.687	0.675	10.0	0.787	0.687	8.0
5	0.750	0.675	9.5	0.812	0.800	8.5
6	0.637	0.450	9.0	0.725	0.612	6.0
6	0.862	0.637	9.0	0.562	0.750	7.0

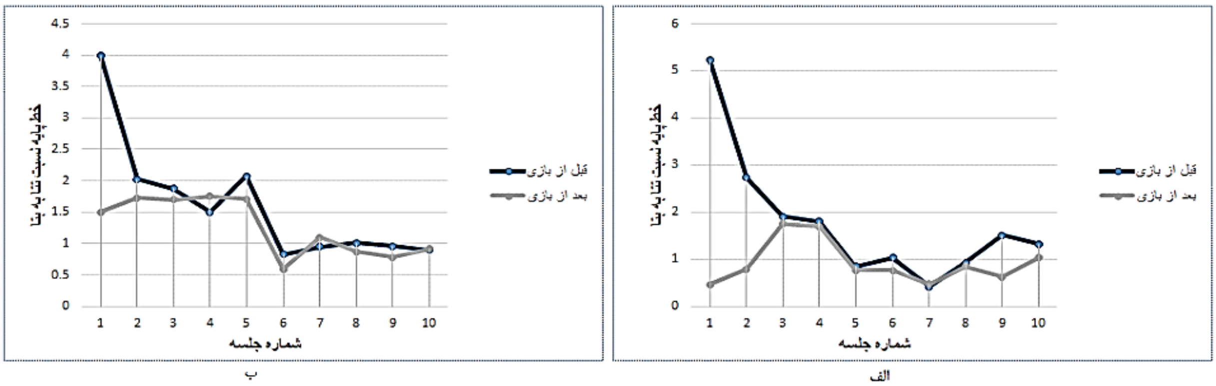

Figure 6. Baseline rate in different sessions; subject No. 1 (13-year-old boy) in the dynamic play (a), subject No. 2 (12-year-old boy) in the static play (b)

The results of the study showed that the dynamic play led to more pleasure and satisfaction in the subjects compared to static play, in addition to improving the brain function of the children with ADHD.

The lower baseline at the end of most sessions than at the beginning of that session indicated that the person was trying to increase their focus throughout the game, which reduced the user's baseline at the end of the game. Furthermore, in some sessions, it was observed that the baseline increased at the end of the session compared to the beginning of the session. For example, this was seen in sessions 4 and 7 of participant number 1 and in session 7 of participant number 2. Since this ratio had a decreasing trend in most cases, it can be assumed that this happened due to the user's fatigue and boredom, as well as his conditions during the day or the relocation of the test site that led to the user's distraction. Additionally, although figure 6 had an oscillating trend, the base line trend had a negative and downward slope during the sessions.

Limitations

Since the investigations in this study was aimed at its practical aspect, the number of treatment sessions was low on only two children with ADHD and single sex.

Recommendations

It is recommended that the present study be conducted on a larger community of children with ADHD and with more sessions to evaluate the therapeutic effect of this method.

Conclusion

The findings of the present study showed that dynamic play creates more pleasure and satisfaction in people compared to the static play. Moreover, the initial assessment of the game use for children with ADHD showed that this approach could have a contributing effect on children's performance; however, more comprehensive investigations are needed to prove this issue scientifically.

Acknowledgments

The present study was one of the articles submitted to the secretariat of the Fifth International Conference on "Computer Games; Opportunities and Challenges" with a special focus on therapeutic games (February 2017, Isfahan), which was praised by the editorial board of the Journal of Research in Rehabilitation Sciences. The authors would like to appreciate the Cyberspace Research Institute, National Cyberspace Center for supporting the publication of this article.

The present study was taken from a M.Sc. thesis in the field of Medical Engineering with the code of ethics IR.UI.REC.1396.021, approved by the University of Isfahan and the code of Iranian Registry of Clinical Trials (IRCT) IRCT20200306046705N11. The authors would like to appreciate the Counseling Center, Education Department, District 3, Isfahan for their cooperation in this study with providing the children with ADHD.

Authors' Contribution

Mina Masoudi: Study design and ideation, supportive, executive, and scientific services of the study, data collection, analysis and interpretation of results, specialized statistical services, manuscript preparation, confirmation of final manuscript for submission to the journal office, responsibility to maintain the integrity of the study process from the beginning to publishing, and responding to the comments of the referees; Javad Rasti: Study design and ideation, supportive, executive, and scientific

services of the study, providing study equipment and samples, analysis and interpretation of results, specialized manuscript in terms of general concepts, confirmation of final manuscript for submission to the journal office, responsibility to maintain the integrity of the study process from the beginning to publishing, and responding to the comments of the referees; Amin Mahnam: study design and idea generation, attracting financial resources to perform the study, supportive, executive, and scientific services of the study, providing study equipment and samples, analysis and interpretation of the results, specialized statistical services, specialized evaluation of the manuscript in terms of general concepts, confirmation of final manuscript for submission to the journal office, responsibility to maintain the integrity of the study process from the beginning to publishing, and responding to the comments of the referees; Ahmad Abedi: Study design and ideation, supportive, executive, and scientific services of the study, providing study equipment and samples, confirmation of final manuscript for submission to the journal office, responsibility to maintain the integrity of the study process from the beginning to publishing, and responding to the comments of the referees; Mohammad Ali Nazari: study design and ideation, supportive, executive, and scientific services of the study, specialized statistical services, confirmation of final manuscript for submission to the journal office, responsibility to maintain the integrity of the study process from the beginning to publishing, and responding to the comments of the referees.

Funding

This study was based on the secondary analysis of the information extracted from a M.Sc. thesis in Medical Engineering with the code of ethics IR.UI.REC.1396.021 and the code of Iranian Registry of Clinical Trials (IRCT) IRCT20200306046705N11 and the financial support of the University of Isfahan and the Cognitive Science and Technology Development Headquarters. This paper was reviewed and published in the Journal of Research in Rehabilitation Sciences with the financial support of the Cyberspace Research Center of the National Cyberspace Center,the sponsor of the Fifth International Conference on “Computer Games; Opportunities and Challenges” with an approach to therapeutic games. This research institute did not contribute to the designing, compiling, and reporting this study.

Conflict of Interest

The authors declare no conflicts of interest.

References

1. Dawson P, Guare R. Executive Skills in children and adolescents: A practical guide to assessment and intervention. New York, NY: The Guilford Press; 2018.
2. Zuberer A, Brandeis D, Drechsler R. Are treatment effects of neurofeedback training in children with ADHD related to the successful regulation of brain activity? A review on the learning of regulation of brain activity and a contribution to the discussion on specificity. Front Hum Neurosci 2015; 9: 135.
3. Volkow ND, Wang GJ, Newcorn J, Fowler JS, Telang F, Solanto MV, et al. Brain dopamine transporter levels in treatment and drug naive adults with ADHD. Neuroimage 2007; 34(3): 1182-90.
4. Jones SR, Gainetdinov RR, Wightman RM, Caron MG. Mechanisms of amphetamine action revealed in mice lacking the dopamine transporter. J Neurosci 1998; 18(6): 1979-86.
5. Lubar JF, Shouse MN. EEG and behavioral changes in a hyperkinetic child concurrent with training of the sensorimotor rhythm (SMR): A preliminary report. Biofeedback Self Regul 1976; 1(3): 293-306.
6. Lubar J, Swartwood M, Swartwood J, Timmermann D. Quantitative EEG and Auditory Event-Related Potentials in the Evaluation of Attention Deficit/Hyperactivity Disorder: Effects of methylphenidate and implications for neurofeedback training. J Psychoeduc Assess 1994; 34: 143-60.
7. Lubar JO, Lubar JF. Electroencephalographic biofeedback of SMR and beta for treatment of attention deficit disorders in a clinical setting. Biofeedback Self Regul 1984; 9(1): 1-23.
8. Lubar JF. Discourse on the development of EEG diagnostics and biofeedback for attention-deficit/hyperactivity disorders. Biofeedback Self Regul 1991; 16(3): 201-25.
9. Clarke AR, Barry RJ, McCarthy R, Selikowitz M. EEG analysis in Attention-Deficit/Hyperactivity Disorder: Acomparative study of two subtypes. Psychiatry Res 1998; 81(1): 19-29.
10. Demos JN. Getting started with Neurofeedback. New York, NY: W. W. Norton & Company; 2005.
11. Van Doren J, Arns M, Heinrich H, Vollebregt MA, Strehl U, Loo K. Sustained effects of neurofeedback in ADHD: a systematic review and meta-analysis. Eur Child Adolesc Psychiatry 2019; 28(3): 293-305.
12. Sterman MB, Wyrwicka W, Howe R. Behavioral and neurophysiological studies of the sensorimotor rhythm in the cat. Electroencephalogr Clin Neurophysiol 1969; 27(7): 678-9.
13. Granic I, Lobel A, Engels RCME. The benefits of playing video games. Am Psychol 2014; 69(1): 66-78.

14. Zohaib M. Dynamic Difficulty Adjustment (DDA) in computer games: A review. Advances in Human-Computer Interaction 2018; 2018: 5681652.
15. Chen J. Flow in games (and everything else). Commun ACM 2007; 50: 31-4.
16. Stein A, Yotam Y, Puzis R, Shani G, Taieb-Maimon M. EEG-triggered dynamic difficulty adjustment for multiplayer games. Entertain Comput 2018; 25: 14-25.
17. Hunicke R. The case for dynamic difficulty adjustment in games. Proceedings of the International Conference on Advances in Computer Entertainment Technology (ACE 2005); 2005 Jun 15; Valencia, Spain. p. 429-33.
18. van der Pal J, Roos C, Sewnath G. Exploring adaptive game-based learning using brain measures. In: Sampson D, Ifenthaler D, Spector JM, Isaias P, editors. Digital Technologies: Sustainable Innovations for Improving Teaching and Learning. Cham, Switzerland: Springer International Publishing; 2018. p. 161-71.
19. Chowdhury MI, Katchabaw M. Bringing auto dynamic difficulty to commercial games: A reusable design pattern based approach. Proceedings of the18th International Conference on Computer Games: AI, Animation, Mobile, Interactive Multimedia, Educational and Serious Games (CGAMES); 2013 Jul 30-Aug 1; Louisville, KY, USA. p. 103-10.
20. Csikszentmihalyi M. Creativity: Flow and the psychology of discovery and invention. New York, NY: Harper Collins; 1996.
21. Shouse MN, Lubar JF. Physiological basis of hyperkinesis treated with methylphenidate. Pediatrics 1978; 62(3): 343-51.
22. Monastra VJ, Lynn S, Linden M, Lubar JF, Gruzelier J, LaVaque TJ. Electroencephalographic biofeedback in the treatment of attention-deficit/hyperactivity disorder. Appl Psychophysiol Biofeedback 2005; 30(2): 95-114.
23. Vidal JJ. Real-time detection of brain events in EEG. Proceedings of the IEEE 1977; 65(5): 633-41.
24. Jasper HH. Report of the committee on methods of clinical examination in electroencephalography. Electroencephalogr Clin Neurophysiol 1958; 10(2): 370-5.