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DO COGNITIVE TRAINING GAMES ACTUALLY WORK FOR ADHD? A LITERATURE REVIEW

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ABSTRACT

ADHD has been studied over years regarding its characteristics, assessments and treatments. However, rapid advances in technology encourages both clinician and clients to search for an acceptable, interesting and better treatment for individuals with ADHD so that they can have better attention and impulse control. Technology helps to enable more specific and personalized treatment which is suitable for ADHD. Difficulties in paying attention, following the rules, and restraining movement is common in ADHD patients. This can be caused by executive function impairment. Therefore, cognitive training is needed. One of the ways to make cognitive training more engaging and pleasurable is through games. It is believed as a promising method to treat individuals with ADHD. The aim of this review is to investigate the alternative treatment for ADHD, especially with the variety of technology, including games. This is a literature review study obtained from research articles and survey books that are relevant to ADHD and cognitive training that was focusing on the last 10 years. To sum up, technology based cognitive training can be an option that shows promising results. However, further studies should consider motivation as it is a crucial role in determining the participant's persistence.

Keywords: *ADHD, cognitive training, technology, games, review*

1. PREFACE

Globally, an estimated 5,29% of the world's population has attention deficit hyperactivity disorder (ADHD). ADHD can be diagnosed by using DSM-5. It is more common in men than women. ADHD is a condition that is characterized by three symptoms of inattention, hyperactivity, and impulsivity and can persist until adulthood. Deficits in attention can make ADHD patients unable to concentrate, have short attention span, and vulnerable to external interference. Hyperactivity in ADHD patients can cause poor inhibition, difficulty to control emotions and behaviours, and impulsivity. Affected subjects have been associated with negative outcomes such as impairment in cognitive, affects daily living, communication, family, social academic, and work domains.

Clinicians nowadays are also offering new and advanced interventions to treat client's mental health issues by providing innovative treatments via technology. The use of technologies has greatly impacted many aspects of our lives and has led to the invasion of more specific intervention for ADHD. Technology based care for cognitive training has demonstrated an advantageous effect on ADHD. Previous studies concluded that cognitive training can reduce the symptoms of ADHD. It has been suggested that this program is effective to treat ADHD. Cognitive Training (CT) is an alternative treatment and is viewed as the most potential treatment. It is a non-pharmacological approach and usually consists of computer-delivered intervention that is composed of many different games related to targeting different neuropsychological domains. There are many types of cognitive training that are available for instance Cogmed Working Memory Training (CWMT) and The Computerized cognitive training program (ACTIVATE™).

Cognitive training mostly targeted on executive functions (EF). Executive dysfunction is common in ADHD. By neuroimaging studies, it is also well identified that ADHD is affecting brain networks that are required for goal-directed behaviours called executive function. EF deficits can cause impairment in motor response, attention, time estimation, foresight capability and working memory. Therefore, it is crucial for a treatment to target EF as it is seen as the most potential treatment.

With pleasurable and interactive games available, it will help to keep ADHD patients stay motivated, as there will be video games. Video games are useful tools in psychotherapy that are very acceptable and interesting for people but still it is suggested that video games are a supplement, not to replace in person psychotherapy.

There are two types of video games offered for therapeutic sessions, EGP (electronic games specifically developed for psychotherapy) and EGE (electronic games for entertainment implemented in a salutary manner in psychotherapy). To sum up, the aim of this review is to update the current empirical studies that examine the involvement of games in providing treatment for ADHD.

ADHD

The etiology of ADHD came from the neurology structure factor (brain damage, lesion on lobus frontal, smaller basal ganglia structure), neurology functional factor (increased beta and theta activity on lobus frontal, hypofrontality), genetic factor (parents with ADHD), and even psychosocial factor (bad parenting and family condition. There are a number of different tools used for screening ADHD, such as BASC-2 and the CBCL. The treatment of ADHD itself has grown a lot, for instance a medication treatment to correct the neural network abnormality, behavioural treatment to treat the inattention and hyperactivity-impulsivity symptoms, and cognitive training to overcome the problems with poor executive functions in ADHD. The extent of people who get diagnosed with ADHD should be a concern not only to identify the disorder but also to get the best treatment as effective and convenient as it can be.

Executive Functions Deficits

ADHD is closely related to low executive functions. For instance, there is research that found the lack of inhibitory control predicts mind wandering frequencies in late childhood which is one of the symptoms of children with ADHD. Executive functions itself is an umbrella term used for various hypotheses of cognitive processes carried out in the prefrontal area of frontal lobes consisting of planning, working memory, attention, inhibition, self-monitoring, self-regulation and initiation. Executive Functioning (EF) deficits may indicate an aspect of ADHD since its two symptom dimensions of ADHD actually represent dimensions of EF. However, one must know that EF impairments especially those who are present in children with ADHD tend to be specific rather than global impairments. Hereafter, serious social and adaptive impairments may be a result of ADHD (EF disorder). Lastly, we can conclude that executive dysfunction is allied with ADHD.

Cognitive Training Games

Based on the understanding of brain plasticity, it is thought that cognitive training can strengthen brain networks affected in ADHD. Computerized cognitive training by using brain games is targeting different cognitive skills, including attention, concentration, verbal and visual working memory, processing speed, and inhibition. Not only useful in improving attention and suppressing impulse, but games also can exercise daily life and social skills.

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2. RESEARCH METHOD

Research Procedure

A framework was used as a guide to identify, select, and review relevant publications in this topic area. A combination of keywords: ADHD; computerized cognitive training; and games, were used to search the electronic databases APA Psycnet and Atlantis Press for publications between 2017 until 2022. Researchers will also implicate other references from textbooks or journals that are considered to be relevant and support this study. This approach is useful and essential to provide an overview of the relationship between games and ADHD as many researchers suggested to leverage technology to provide better treatment for those with ADHD.

Inclusion Criteria

Articles published are included if the articles meet the following criterion such as published in English or Indonesia, have empirical data that are valid and reliable, investigate the effectiveness of games to ADHD with the aim to reduce ADHD symptoms, and tested on children and adults. The systematic search yielded 10 publications. After eliminating the articles at the title and abstract level, five articles remained and were subsequently read. A total of 5 publications were eliminated for not focusing on only games intervention and one of them was written as a systematic review publication. Thus, five articles were identified as relevant.

Data Extraction

Data that were extracted from the article comprised of author (s), year of publication, country, study design, participants characteristics, interventions, and outcome measures. A descriptive approach was used to summarize the data.

3. RESULT AND DISCUSSION

From the five articles, four studies had experimental study design with treatment and control group and one study had a study case design. In total, all studies combined included 98 children and adolescents with ADHD aged 8 to 17 years old. Geographically, one was performed in Indonesia; three in Brazil; and one in Denmark. In five articles, ADHD was assessed using DSM V and ICD-10 criteria. The results from four studies shows that computerized cognitive training is giving significant effect on decreasing ADHD symptoms, while one study shows that there is no significant effect of computerized cognitive training on ADHD patients. To determine whether games have impacts on ADHD, we look into three different types of games based on 5 literature reviews. The results show that computerized cognitive training games may decrease symptoms significantly and also not show a significant outcome for people with ADHD.

ADHD Trainer is one of the cognitive training applications designed to improve cognitive impairment such as attention, working memory, processing speed, mental calculation, reasoning, and visual-motor coordination. ADHD Trainer consisted of three games that each targeted different cognitive function. After the game session, the game taker will be given a score and the taker's score will be stored in the database. Later, game takers can choose specific games to train their cognitive function weaknesses. Giving ADHD Trainer for 10 days with at least 10 minutes of gameplay has shown to decrease inattention and hyperactivity. While ADHD Trainer has shown to improve attention and decrease hyperactivity, it turns out that one of the cognitive training programs, such as CCT (Cognitive Computerized Remediation Training) ACTIVATE had no significant effect in patients with ADHD. CCT-ACTIVATETM is a computerized training consisting of six different games and different levels of difficulty that are designed to address different neurocognitive domains, such as working memory, speed processing, sustained and

divided attention, category formation, and control inhibition which target one of the executive function's components. Although CCT ACTIVATE showed no significant effect in patients with ADHD, in an fMRI study, twenty children with ADHD given CCT-ACTIVATE activated more brain area that is associated with working memory and sustained attention. It is also found that methylphenidate activates the same brain area. These findings suggest that cognitive training and psychostimulant medication might have the same effect on ADHD patients.

On the other hand, CCT-ACTIVATE had a different outcome when given to 6 ADHD patients in children aged 10-12 years old. This is an experimental study wherein the active condition group, participants were given CCT-ACTIVATE intervention while non-active conditions were given educational videos and questions related to school content that was developed by a learning tutor and psychologists. Other computerized cognitive training games are Scientific Brain Training (SBT) and Tetris. They both had significant outcomes on cognitive and symptoms of ADHD. Scientific Brain Training is a computerized training game consisting of 6 exercises, which are entangled figures, shapes and colours, under pressure, displaced characters, heraldry, "Objects, where are you?". Where SBT had a significant beneficial effect on sustained attention and the active placebo had significant beneficial effects on working memory.

Table 1
The Results of This Study

Author(s)	Year	Country	Study design	Population and sample size	Results
Bikic et al.	2017	Denmark	Double-blind randomized pilot trial	18 participants with ADHD, age between 14–17 years that were divided into two groups.	SBT had a significant effect on sustained attention, whereas the active placebo (Tetris) had significant beneficial effects on working memory
de Oliveira Rosa et al.	2017	Brazil	Randomized clinical trial	6 ADHD patients aged 10-12-years that were divided into active or placebo conditions.	Both active and placebo condition showed decrease in ADHD symptoms without statistical difference between them and there's a need for new strategies to better assess the effectiveness of cognitive training in a school environment to have an assessment
de Oliveira Rosa et al.	2018	Brazil	Randomized clinical trial	35 participants aged 6 to 13 years receiving stimulant treatment were randomized either to a computerized cognitive training (CCT) or to controlled non-active condition.	This study does not provide evidence for the benefits of cognitive training over non-active training on core ADHD symptoms in medicated ADHD children and adolescents.
de Oliveira Rosa et al.	2019	Brazil	Randomized controlled clinical trial	20 children with ADHD aged 9 to 13 years randomized either to a CCT or to a controlled non-active condition.	Cognitive training was associated with activation of the brain area that regulates attention and working memory, but not in inhibitory control.
Agustini, M.	2019	Indonesia	Experimental Study	One boy with ADHD aged 8 years.	ADHD Trainer improves cognitive skills by training the cognitive areas.

Presently, there are numbers of literature that combine psychology intervention and technology with ADHD. Based on the three studies, all the presented games (ADHD Trainer, CCT-ACTIVATETM, and SBT) target the executive function to reduce the ADHD symptoms

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(inattentive, hyperactivity-impulsivity). In addition, many other games-based interventions have proven their effectiveness in diagnosing and treating ADHD. Video game-based interventions have been used in cognitive training and could help in the formation and restructuring of neurobiological pathways, especially in children as a child's brain displays plasticity. Generally speaking, this intervention is more effective in children with ADHD. It requires players to use executive functioning skills that include planning, time management, and working memory. Movement, intense activity, and frequent changes in games mesmerized children with ADHD for the fact that cognitive training task difficulty is increasing from session to session in a way to challenge the patient to go beyond their competence. Neuroimaging studies show that increasing difficulty is needed to support neuronal changes Neuronal changes are crucial as deficits in neuropsychological can serve as a bridge between originating causes and disorder onset and it is for proper brain function. It should be noted that cognitive training intervention not only affected the performance gains on the trained dimensions of EF, but also generalized to other cognitive functions and everyday activities so that it will persist over longer periods.

Astoundingly, based on previous research about the implementation of computerized cognitive training on ADHD. One of its limitations is motivation. For instance, children with ADHD prefer quick alternatives and find it difficult to make peer relationships. This will lead them to reject games that require cooperation and linguistic abilities. Therefore, one way to make children cooperate with the games is by strengthening motivation because it is important to have an understanding of how interactive games enhance the learning process. Furthermore, following the previous study, measuring the motivation rates of each participant is necessary due to low levels of motivation could lead to negative influences on the treatment effects. Not all individuals find all computer game-based learning motivating and interesting. However, a group of participants in a research study said that they would consider the idea of game-based learning if they believe that it is the most effective way to learn. Again, considering individual differences such as motivational aspects could moderate the number of training-induced gains. What's more, the results from the previous study also mentions that motivation is an important thing to sustain the focus of adolescents with ADHD on cognitive training because both teenagers in the groups found they had low scores on Interest and Value in the APQ that may have negative influences on treatment effects.

Technology has proven to be helpful in various ways and yet we still need to consider the bug that may happen when we use technology as the tool for intervention. For example, the quality of high-speed internet availability is crucial at home for developing any session. Even though countless studies are focusing on the association between electronic media and greater difficulties with attention, it is essential to identify the value of using electronic media for increasing focus and self-control. To sum up, besides targeting executive function in children and adolescents with ADHD, we need to pay attention to the process of the training games.

4. CONCLUSIONS AND RECOMMENDATIONS

This paper has provided a brief review of different use of games for the intervention of ADHD. We discussed three different games particularly ADHD Trainer, CCT-ACTIVATETM, and SBT. ADHD Trainer, SBT and CCT-ACTIVATETM have been shown to decrease ADHD symptoms, while CCT-ACTIVATETM also had no significant effect in patients with ADHD. It is assumed that motivation also plays a role in supporting symptom reduction through games.

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REFERENCE

A. Bikic, T. Christensen, J. Leckman, N. Bilenberg and S. Dalsgaard, "A double-blind randomized pilot trial comparing computerized cognitive exercises to Tetris in adolescents with attention-deficit/hyperactivity disorder", Nordic Journal of Psychiatry, vol. 71, no. 6, pp. 455-464, 2017. Available: 10.1080/08039488.2017.1328070 [Accessed 8 March 2022].

A. Veloso, S. G. Vicente, and M. G. Filipe, "Effectiveness of cognitive training for school-aged children and adolescents with attention deficit/hyperactivity disorder: A systematic review," Frontiers in Psychology, vol. 10, 2020.

B. G. Jurigova, M. R. Gerdes, J. A. Anguera, and E. J. Marco, "Sustained benefits of cognitive training in children with inattention, three-year follow-up," PLOS ONE, vol. 16, no. 2, 2021.

C. G. Lim., N. S. J. Lim-Ashworth, and D. S. S. Fung, 2020. Updates in technology-based interventions for attention deficit hyperactivity disorder. Current Opinion in Psychiatry, 33(6), pp.577-585.

C. M. Lewis, A. Baldassarre, G. Committeri, G. L. Romani, and M. Corbetta, "Learning sculpts the spontaneous activity of the resting human brain," Proceedings of the National Academy of Sciences, vol. 106, no. 41, pp. 17558–17563, 2009.

D. Coghill, J. Nigg, A. Rothenberger, E. Sonuga-Barke, and R. Tannock, "Whither causal models in the neuroscience of ADHD?" Developmental Science, vol. 8, no. 2, pp. 105–114, 2005.

D. H. Barlow, V. M. Durand, and S. G. Hofmann, Abnormal psychology: An integrative approach. Boston, MA: Cengage Learning, 2018.

de Oliveira Rosa, V., Franco, A. R., Salum Júnior, G. A., Moreira-Maia, C. R., Wagner, F., Simioni, A., de Fraga Bassotto, C., Moritz, G. R., Aguzzoli, C. S., Buchweitz, A., Schmitz, M., Rubia, K., & Paim Rohde, L. A. (2020). Effects of computerized cognitive training as add-on treatment to stimulants in ADHD: A pilot fMRI study. Brain Imaging and Behavior, 14(5), 1933–1944. https://doi.org/10.1007/s11682-019-00137-0

Diagnostic and statistical manual of mental disorders: DSM-5. Arlington, VA: American Psychiatric Association, 2017.

E. Alabdulakareem and M. Jamjoom, "Computer-assisted learning for improving ADHD individuals' executive functions through gamified interventions: A Review," Entertainment Computing, vol. 33, p. 100341, 2020.

E. G. Willcutt, E. J. S. Sonuga-Barke, J. T. Nigg, and J. A. Sergeant, "Recent developments in neuropsychological models of childhood psychiatric disorders," Biological Child Psychiatry, pp. 195–226, 2008.

E. H. H. Keulers and L. M. Jonkman, "Mind wandering in children: Examining task-unrelated thoughts in computerized tasks and a classroom lesson, and the association with different executive functions," Journal of Experimental Child Psychology, vol. 179, pp. 276–290, 2019.

E. J. Mash and R. A. Barkley, Child psychopathology. New York: The Guilford Press, 2014.

G. Polanczyk, M. S. de Lima, B. L. Horta, J. Biederman, and L. A. Rohde, "The worldwide prevalence of ADHD: A systematic review and metaregression analysis," American Journal of Psychiatry, vol. 164, no. 6, pp. 942–948, 2007.

H. J. Chung, L. L. Weyandt, and A. Swentosky, "The physiology of executive functioning," Handbook of Executive Functioning, pp. 13–27, 2013.

H. M. Geurts, M. Luman, and C. S. van Meel, "What's in a game: The effect of social motivation on interference control in boys with ADHD and autism spectrum disorders," Journal of Child Psychology and Psychiatry, vol. 49, no. 8, pp. 848–857, 2008.
I. M. Loe and H. M. Feldman, "Academic and educational outcomes of children with ADHD," Journal of Pediatric Psychology, vol. 32, no. 6, pp. 643–654, 2007.
I. Marton, J. Wiener, M. Rogers, C. Moore, and R. Tannock, "Empathy and social perspective taking in children with attention-deficit/hyperactivity disorder," Journal of Abnormal Child Psychology, vol. 37, no. 1, pp. 107–118, 2008.
I. Peñuelas-Calvo, L. K. Jiang-Lin, B. Girela-Serrano, D. Delgado-Gomez, R. Navarro-Jimenez, E. Baca-Garcia, and A. Porras-Segovia, "Video games for the assessment and treatment of attention-deficit/hyperactivity disorder: A systematic review," European Child & Adolescent Psychiatry, vol. 31, no. 1, pp. 5–20, 2020.
J. Holmes, S. E. Gathercole, and D. L. Dunning, "Poor working memory," Developmental Disorders and Interventions, pp. 1–43, 2010.
J. Holmes, S. E. Gathercole, and D. L. Dunning, "Poor working memory," Developmental Disorders and Interventions, pp. 1–43, 2010.
J. Karbach and J. Kray, "Executive functions," Cognitive Training, pp. 93–103, 2016.
J. Stone and R. Altvater, "Research-informed technological transitions in psychotherapy.," in Integrating technology into Modern Therapies: A clinician's guide to developments and interventions, New York, NY: Routledge, 2019, pp. 10–23.
J. Stone, Integrating technology into Modern Therapies: A clinician's guide to developments and interventions. New York, NY: Routledge, 2019.
K. M. Antshel, B. O. Hier, and R. A. Barkley, "Executive functioning theory and ADHD," Handbook of Executive Functioning, pp. 107–120, 2014.
K. Rubia, 'cool' inferior frontostriatal dysfunction in attention-deficit/hyperactivity disorder versus 'hot' ventromedial orbitofrontal-limbic dysfunction in conduct disorder: A Review," Biological Psychiatry, vol. 69, no. 12, 2011.
K. Rubia, "Cognitive neuroscience of attention deficit hyperactivity disorder (ADHD) and its clinical translation," Frontiers in Human Neuroscience, vol. 12, 2018.
K. Rubia, R. Halari, A. Christakou, and E. Taylor, "Impulsiveness as a timing disturbance: Neurocognitive abnormalities in attention-deficit hyperactivity disorder during temporal processes and normalization with methylphenidate," Philosophical Transactions of the Royal Society B: Biological Sciences, vol. 364, no. 1525, pp. 1919–1931, 2009.
L. Baker. "Therapy in the digital age," In J. Stone (Ed.), Integrating technology into modern therapies: A clinician's guide to developments and interventions, Routledge/Taylor & Francis Group, 2019, pp. 37–47
M. Agustini, "Usage 'ADHD trainer' game to improve cognitive skill child with ADHD (the study cases at the child aged 8 years)," Proceedings of the 1st International Conference on Early Childhood Care Education and Parenting (ICECCEP 2019), 2020.
M. L. van der Donk, A.-C. Hiemstra-Beernink, A. C. Tjeenk-Kalff, A. van der Leij, and R. J. Lindauer, "Predictors and moderators of treatment outcome in cognitive training for children with ADHD," Journal of Attention Disorders, vol. 24, no. 13, pp. 1914–1927, 2016.
N. Whitton, "Motivation and computer game-based learning," Proceedings of ASCILITE - Australian Society for Computers in Learning in Tertiary Education Annual Conference 2007, pp. 1063–1067, 2007.
R. A. Poldrack and J. D. Gabrieli, "Characterizing the neural mechanisms of skill learning and repetition priming," Brain, vol. 124, no. 1, pp. 67–82, 2001.
S. Dovis, S. Van der Oord, R. W. Wiers, and P. J. Prins, "Improving executive functioning in children with ADHD: Training multiple executive functions within the context of a computer

game. A randomized double-blind placebo controlled trial," PLOS ONE, vol. 10, no. 4, 2015.
S. Goldstein, J. A. Naglieri, D. Princiotta, and T. M. Otero, "Introduction: A history of executive functioning as a theoretical and clinical construct," Handbook of Executive Functioning, pp. 3–12, 2014.
S. Vinogradov, M. Fisher, and E. de Villers-Sidani, "Cognitive training for impaired neural systems in neuropsychiatric illness," Neuropsychopharmacology, vol. 37, no. 1, pp. 43–76, 2012.
S. Young and G. H. Gudjonsson, "ADHD symptomatology and its relationship with emotional, social and delinquency problems," Psychology, Crime & Law, vol. 12, no. 5, pp. 463–471, 2006.
V. Colombo, D. Baldassini, S. Mottura, M. Sacco, M. Crepaldi, and A. Antonietti, "Antonyms: A serious game for enhancing inhibition mechanisms in children with attention deficit/hyperactivity disorder (ADHD)," 2017 International Conference on Virtual Rehabilitation (ICVR), 2017.
V. de Oliveira Rosa et al., "Computerized Cognitive Training for ADHD as an Add-On Treatment to Stimulants: A Randomized Clinical Trial", Journal of Attention Disorders, vol. 25, no. 2, pp. 275-285, 2018. Available: 10.1177/1087054718816818 [Accessed 8 March 2022].
V. Noreika, C. M. Falter, and K. Rubia, "Timing deficits in attention-deficit/hyperactivity disorder (ADHD): Evidence from neurocognitive and neuroimaging studies," Neuropsychologia, vol. 51, no. 2, pp. 235–266, 2013.
V. Rosa et al., "Computerized cognitive training in children and adolescents with attention deficit/hyperactivity disorder as add-on treatment to stimulants: feasibility study and protocol description", Trends in Psychiatry and Psychotherapy, vol. 39, no. 2, pp. 65-76, 2017. Available: 10.1590/2237-6089-2016-0039 [Accessed 8 March 2022].