Multimodal Technologies and Interaction

MDPI

Systematic Review

Managing ADHD Symptoms in Children Through the Use of Various Technology-Driven Serious Games: A Systematic Review

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Abstract: Children with attention deficit hyperactivity disorder (ADHD) frequently experience impairments in a range of abilities. Due to their poor attention and concentration, they find it challenging to stay focused when learning. They need help to retain the directions given by teachers and are very animated. Focus issues, hyperactivity, and attention problems may hamper learning. The needs and challenges of children with ADHD have been addressed by numerous digital solutions over the years. These solutions support a variety of needs (e.g., diagnosing versus treating), aim to address a variety of goals (e.g., addressing inattention, impulsivity, working memory, executive functions, emotion regulation), and employ a wide range of technologies, including video games, PC, mobile, web, AR, VR, tangible interfaces, wearables, robots, and BCI/neurofeedback, occasionally even in tandem. According to studies on the psychological impacts of serious games, immersive games can potentially be valuable tools for treating ADHD. This research investigates using PC, mobile/tablet applications, augmented reality, virtual reality, and brain–computer interfaces to develop executive functions and metacognitive and emotional competencies in children with ADHD through serious games. Following PRISMA 2020 criteria, this systematic review includes a comprehensive search of the PubMed, Web of Science, Scopus, and Google Scholar databases. The database search provided 784 records, and 30 studies met the inclusion criteria. The results showed that serious games assisted by multiple technologies could significantly improve a wide range of cognitive and socioemotional meta-competencies among children with ADHD, including visuospatial working memory, attention, inhibition control, cognitive flexibility, planning/organizing, problem-solving, social communication, and emotional regulation. The results of this review may provide positive feedback for creating more inclusive digital training environments for the treatment of ADHD children.

Keywords: attention deficit hyperactivity disorder; serious games; virtual reality; augmented reality; computers; mobile applications; brain–computer interface; video games; neurofeedback; executive functions; emotional intelligence; metacognition; attention; impulsivity

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1. Introduction

Inattention, impulsivity, and hyperactivity are the significant symptoms of attention deficit hyperactivity disorder or ADHD. Generally speaking, the incidence of ADHD is around 7.2% [1], with boys showing greater prevalence than girls [2], but this varies significantly depending on the diagnostic criteria used. A large number of children have

ADHD. Children with attention deficit hyperactivity disorder (ADHD) have short attention spans, difficulty focusing, and are more susceptible to outside distractions. Children with a hyperactivity condition are impulsive, have poor inhibition, and struggle to manage their emotions and behaviors. They are disadvantaged in many facets of daily life as a result of these ADHD symptoms. Many academic issues plague children with ADHD, including difficulty focusing in class, difficulty finishing schoolwork on their own, and a high likelihood of dropping out of school [3].

Additionally, children with ADHD frequently struggle with reading comprehension and verbal expression, which is highly harmful to their normal development [4,5]. Additionally, children with ADHD display excessive behaviors in society, such as a propensity for arguments with friends and family and an inability to interact with people in a usual manner. Children who have ADHD are also at risk of developing other mental health conditions such as depression, conduct disorder, and oppositional defiant disorder [6].

Medication is typically used to treat ADHD symptoms, but it can have harmful side effects and lead to dependence [7]. New technology began to be used to cease ADHD medication as science and the digital world advanced. As a result, serious games that fulfill the training goal while providing entertainment have been effectively used to treat ADHD. There are a lot of serious games for ADHD these days, and because of various technological advancements, these games have varying effects. According to studies, severe causes of ADHD are essentially split into two categories: diagnosis and treatment. They also employ several carriers to ensure the game runs smoothly [8].

Children with ADHD can benefit from using serious games as an additional tool to strengthen their executive function, practice social and everyday life skills, and engage in cognitive training in addition to reducing their symptoms [9]. In summary, serious games can serve as a diagnostic and therapeutic tool for children with ADHD and offer them a great deal of hope. This report categorizes the various video game carriers into five groups based on the research on serious games: PC-based games, games that use a brain–computer interface (BCI) or neurofeedback, games that run on mobile devices or tablets, games that use virtual reality, and games that use augmented reality.

Computer games designed for children with ADHD can have a range of therapeutic impacts, and the majority of serious games are made for computers. Children with ADHD can have their electroencephalograms (EEGs) detected by combining computer games with brain–computer interface (BCI) technology. Neural feedback technology can also be used to help them improve their attention. General entertainment games require sophisticated brain wave understanding and differ from serious games with BCI technology. In order to lessen the difficulties of game development, Sung's research included a development framework for such games [10].

Mobile games are very popular with children because they are portable and straightforward to use. The majority of mobile games operate on smartphones and tablets. To finish the game, children click and drag on the touch screen with their fingers. Thanks to the numerous serious games created for mobile platforms, children with ADHD can now receive treatment at any time and from any location [11].

The image synthesis technology of virtual reality (VR) combines acoustic effects to create a virtual world. It is widely employed in various industries, including education, medical training, and gaming. For example, Burdea and Coiffet [12] suggested that the three "I" types of virtual reality are imagination, immersion, and interactivity. Immersion means that the 3D virtual world gives users the sense of being in the real world; interaction refers to the ability of users to engage with the virtual environment's items and avatars and receive real-time replies; and imagination means that there are countless possibilities in the

virtual world, where virtual characters and objects can be created even if they do not exist in the real world.

Creating serious games in addition to technology-enhanced teaching strategies like augmented reality (AR) is another crucial difficulty. AR is the real-time digital and physical data integration that enables users to interact with virtual and physical worlds [13]. This innovative, cutting-edge technology has enormous promise for inspiring students with fresh challenges and offering prompt feedback customized to each student's unique requirements and interests. Using simulation and experimentation controlled by bodily movements (interface), these augmented reality serious games could draw their attention and improve communication by combining virtual and real-world elements to create augmented effects [14].

This paper uses a systematic review methodology to examine sources using PRISMA 2020 principles. From the treatment perspective, we studied serious games and compared and analyzed their technology and effects to inform readers about the potential effects on ADHD. We specifically looked for sources in the databases Google Scholar, Web of Science, PubMed, and Scopus. Our research has established a solid basis for serious future game development in ADHD. Because it emphasizes how serious games can help children with ADHD develop their cognitive and socioemotional meta-competencies, the study significantly contributes to serious games research.

The remaining part of this article is organized as follows. Section 2 theoretically discusses executive functions, metacognitive skills, and emotional intelligence and suggests aspects that either improve or hinder their functioning. Section 3 then presents the research methodology. Sections 4–6, which detail the results, discussion, and research conclusions, finally wrap up the paper.

2. Theoretical Knowledge

2.1. Executive Functions

The everyday issues that children with ADHD face are caused by deficiencies in cognitive control skills, according to new neurobiological theories of ADHD [15]. Working memory (WM), inhibition, and cognitive flexibility are examples of cognitive control functions, also known as executive functions (EFs), that enable self-regulation by enabling people to control their thoughts, emotions, and actions. WM is the capacity to preserve, manage, and work with information pertinent to the purpose. It facilitates goal-directed behavior, planning, problem-solving, and reasoning [16]. Deficits in attention, hyperactivity, and impulsivity have been linked to WM impairments in children with ADHD. Stopping or slowing an overlearned, continuous, competitive, or disruptive behavior is known as inhibition. ADHD disrupts the inhibition of a continuous reaction. The capacity to change one's beliefs or behavior in response to changing circumstances is known as cognitive flexibility [17,18]. According to meta-analyses, children with ADHD show less cognitive flexibility, but more impairment in WM (particularly visuospatial WM) and inhibition [19,20]. In addition to EF deficiencies, children with ADHD struggle with motivation: they respond to rewards and punishments differently than typical controls [21]. They require potent reinforcements and choose instant over delayed gratification to function at their best. The behavioral differences between children with ADHD and typical controls are less noticeable when reinforcers are strong and used frequently. Given the strong correlation between reward and motivation, research indicates that children with ADHD may have performance deficiencies due to intrinsic motivation or abnormally low effort levels. Children with ADHD will have a concise attention span when tasks are dull or unsupervised. Children with ADHD may be able to maximize their motivational state and normalize their performance by incorporating external incentives into an otherwise

dull task [21]. From a therapeutic standpoint, new child-focused ADHD therapies should target the deficiencies in both EFs and motivation in order to maximize the performance of ADHD children.

2.2. Metacognitive Abilities

It is worthwhile to investigate the relationship between metacognition and functional impairment in ADHD, since metacognition may impact a variety of functional outcomes, such as social functioning and academic performance [22]. The ability to reflect on one's thoughts is known as metacognition. Conversely, metacognition can be defined as considering the knowledge and abilities in the individual's mind [23]. The "center" of metacognitive abilities, according to a multilevel metacognition model proposed in a study by Drigas and Mitsea [24–26], is internal attention, which participates in processes such as selecting, filtering, suspending, processing, storing, retrieving, predicting, monitoring, adjusting, adapting, recognizing, differentiating, remembering, and knowledge transformation. Each paradigm level depicts a superior control system that shows the individual's metacognition growth. Moving from the lowest to the highest levels of metacognition causes a change in self-awareness and self-observation, leading to a more complex control system. Without having established these metacognition pillars, people cannot include the cognitive and socioemotional skills needed for social integration. Metacognition is the most essential tool for self-education, self-improvement, and self-medication [27]. It should therefore be the main focus of a particular intervention program that promotes holistic learning.

2.3. Emotional Intelligence

Emotional intelligence (EI) in people with ADHD has been the subject of very few published studies, and none of them included a child sample. EI and ADHD symptoms were found to be inversely correlated by Fleming and Snell (2008), who found that university students with lower EI scores showed more signs of ADHD symptomatology [28]. A significant area in which children with ADHD struggle is self-regulation, which is closely connected to emotional intelligence. Emotional intelligence is the control panel for perception, thought, cognition, discernment, and problem-solving. It also emphasizes the traits of self-regulation, including the capacity to suppress impulsive behavior (ego power), tolerate irritants, and postpone pleasure [29]. Based on their findings, Drigas and Papoutsi [30] propose a hierarchically leveled approach to emotional intelligence development that illustrates an individual's evolution across time. In the actual world, this method can be applied as a therapeutic tool to address problems in social relations, special education, and many other facets of life. More specifically, these levels are linked to self-actualization, self-awareness, self-management, empathy, social skills, and the ability to recognize and interpret emotional cues.

3. Materials and Methods

Evidence regarding the effectiveness of technology-based activities in developing cognitive, metacognitive, and emotional/social skills in children with ADHD was gathered and synthesized in this systematic review study. Additionally, we looked into how well serious games for PCs, brain–computer interface (BCI)/neurofeedback, mobile/tablets, VR, and AR can train children with ADHD. Through this study, we attempted to answer the following research questions.

- RQ1. How many technologies were observed to pair with serious games aiming to manage ADHD symptoms in children with ADHD?
- RQ2. How do serious games through the utilization of a variety of different technologies affect specific cognitive skills (executive functioning and metacognitive skills) in

children with ADHD, including attention, working memory, emotional regulation, and inhibitory control? This investigation was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Statement (PRISMA) standards, preregistered with the Open Science Framework (https://osf.io/dx84k/, accessed on 12 November 2024). Four authors conducted a systematic investigation for the current paper between September 2024 and November 2024.

Studies were chosen for additional processing and assessment based on the inclusion and exclusion criteria. More precisely, we considered studies that only addressed the use of serious digital games to improve executive functions, metacognition, and affective abilities while addressing symptoms of ADHD. The necessity to obtain precise and focused data in line with the goals of this study was the basis for this decision. Only studies that used particular technologies—like PCs, VR, AR, BCI, and mobile applications—were chosen because of their demonstrated ability to improve cognitive and executive abilities. The articles we have chosen to present were in English and published between 2013 and 2024. The selection of this time frame is supported by the fact that technology has advanced so quickly in the last ten years that earlier research is less indicative of the potential of serious games for therapeutic and educational objectives. More access to excellent scientific research and the capacity to assess it in English were the reasons for the language selection. The majority of the included studies examined children with a clinical diagnosis of ADHD who were between the ages of 6 and 13. Because executive functions are more responsive to interventions at this age, this decision was made. We mainly focused on studies that recruited participants with ADHD. However, comorbidity studies were not excluded if their results were significant regarding the development of cognitive, metacognitive, and affective skills in ADHD. Additionally, if a study involved the use of new technology to treat ADHD, it did not exclude research from participants who were not ADHD-diagnosed. On the other hand, systematic reviews, meta-analyses, book chapters, and posters were excluded. This exclusion guaranteed the utilization of only primary research with new data. Serious game frameworks without testing and studies not written in English were also excluded. We placed particular importance on research that shows how children with ADHD develop their executive functions and metacognitive and emotional competencies. Studies that concentrated on the general applications of serious games without a clear connection to cognitive or metacognitive processes were excluded. Unless there was unambiguous evidence for children with ADHD, studies that only examined people with other neurodevelopmental disorders (such as autism or learning impairments) were disqualified. Finally, research that did not provide precise or comprehensive information on the intervention's effects was disqualified.

PRISMA 2020 principles (Figure 1) served as the foundation for the technique used to carry out this systematic review, which directed the literature search of the databases PubMed, Web of Science, Scopus, and Google Scholar. The search was limited to articles published between 2000 and 2024. The database search was carried out using a combination of keywords. Specifically, we used the keywords "brain–computer interface", "attention deficit hyperactivity disorder", "serious games", "virtual reality", "augmented reality", "mobile applications", "metacognitive skills", "executive functions", "attention", "self-regulation", "emotional control", and "emotional intelligence".

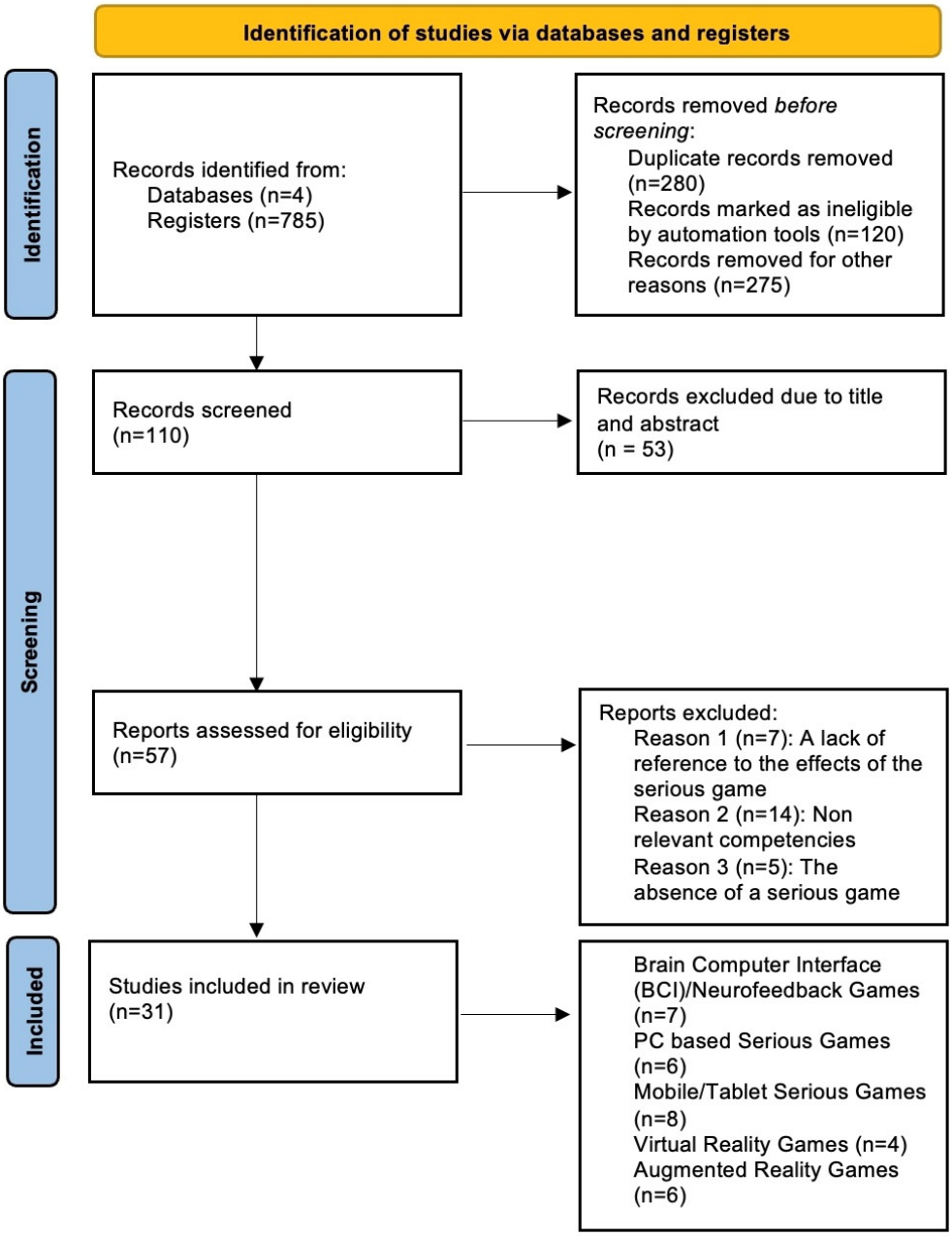

Figure 1. PRISMA 2020 flowchart.

A total of 785 articles were identified and screened for the final selection of included articles, which concluded after the processing, inclusion, and application of representative criteria for the leading group of articles (n = 30) for the final selection, with further investigation and analysis. The articles selected were produced between 2013 and 2024. In the preliminary search, 280 studies were common and removed, 120 were ineligible because there were data issues with the particular surveys, such as uncertainty about the demographics and diagnoses of the survey respondents, and 275 were removed for other reasons. In the specific surveys, there was a lack of completeness, non-compliance with the inclusion criteria, and low-quality data. Investigations were also carried out in very short periods. In addition, the use of VR, AR, PC, BCI, and mobiles/tablets as inclusion criteria further reduced the results. In sum, 110 records were screened, and 53 were excluded based on irrelevant title and abstract. The remaining 57 studies were assessed for eligibility. A total of 26 articles were excluded for failing to meet the eligibility criteria related to not mentioning the effects of the serious game, nonrelevant competencies, and not involving serious games.

This process led to 31 studies that met all eligibility criteria. For brain–computer interface (BCI)/neurofeedback games, we selected 7 studies; for PC-based serious games, we selected 6 studies; for mobile/tablet serious games, we selected 8 studies; for virtual reality games, we selected 4 studies; and for augmented reality games, we selected 6 studies.

4. Results

Digital game-based learning (GBL) is the hallmark of the 21st century according to Boot et al. [31]. A game-based learning environment (GBL) is one in which gameplay and content improve knowledge and skill acquisition and where game activities include challenges and problem-solving areas that provide players/learners with a sense of accomplishment [32]. Digital tools are practically everywhere these days. Both information gathering and entertainment—often through video games—are common uses for them. One of the primary forms of entertainment for children, teens, and adults is video gaming, which has developed into a significant social and cultural tool [33].

A subset of video games known as serious games (SGs) are employed in various contexts for therapeutic and educational objectives [34]. In contrast, the goals and applications of SGs are outcome-driven, even though they use many of the same technologies as traditional video games. In this regard, it is crucial to specify the goals, material, abilities, and behaviors to be developed while keeping in mind the technological, artistic, and narrative resources that promote playability and engagement—all of which are crucial components of a video game [35]. Video games can introduce educational and assessment goals without compromising enjoyment according to authors like Starks [36], who advocate for their pedagogical usage through an engaging and significant approach. The instructional design separates a commercial video game from a pedagogical tool or one with an educational objective (a serious game). Despite having similar technology, their purposes and goals are pretty different. Without sacrificing video games' technical, narrative, and aesthetic elements that promote playability and engagement, serious games have clearly stated goals, content, evaluation processes, and skills and competencies to be developed [36].

The effects of SGs on children with attention deficit hyperactivity disorder (ADHD) have been studied concerning the attentional component [37–44]. In a sample of ADHD children who received an SG intervention, the authors observed gains in planning/organization and time management, as well as a decrease in hyperactive symptoms. Furthermore, compared to non-experts, experienced video gamers exhibited superior visual attention, particularly in perceptual threshold and visual processing speed, according to Schubert et al. [45]. Personal attributes like intelligence, personality, or health state did not mitigate these impacts.

Reading skills [46,47], vocabulary, language learning, listening [48–50], spelling [51,52], mathematics [53], and even affective-motivational components [54] have all been demonstrated to benefit from these tools in recent studies. A critical factor in explaining the beneficial outcomes documented in this research is that SG activities provide students with an enjoyable learning experience while being motivationally demanding. Using captivating storylines and technical elements in serious games can boost student motivation to learn and engage, guaranteeing game participation. Positive emotions generated by exertion and conquering challenges are associated with higher levels of engagement, and they are crucial components in transforming a video game into an instructional tool (i.e., serious games) [55]. Figure 2 presents the positive effects in different areas of serious games through multiple technologies.

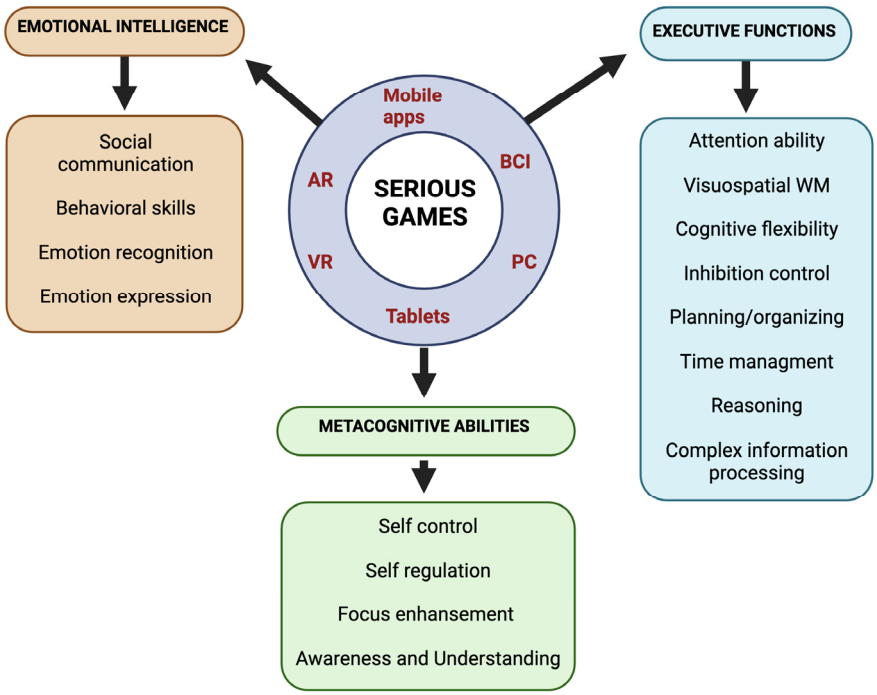

Figure 2. Serious games and areas of improvement through multiple technologies.

4.1. Brain–Computer Interface (BCI)/Neurofeedback Games

People with neurological diseases like attention deficit hyperactivity disorder (ADHD) can regain function with the use of a new technological intervention system called a brain–computer interface (BCI). To help children with ADHD with their inattentive symptoms, Lim et al. [56] created the attention-training serious game *Cogoland*, which is based on a brain–computer interface (BCI). During the training sessions, participants wear a BCI headset that uses dry EEG electrodes to detect their brain waves and use a tablet. An algorithm that powers the game interface analyzes EEG data sent to the tablet via Bluetooth, enabling players to adjust their avatar's speed based on their level of focus. The faster the avatar moves, the "higher" the participant's degree of focus. The ADHD-RS's clinician- and parent-rated inattentive symptom ratings improved similarly for participants in the home-based and clinic-based groups. The results of this study indicate that the tablet-based version of this brain–computer interface attention training program can be safely administered in patients' homes with little technical assistance and without the need for on-site therapist supervision.

Jiang et al. created a 3D game based on BCI for attention training and rehabilitation tailored for ADHD participants [57]. This method converts the user's attentional state into game control using BCI 3D technology. The BCI engine gauges the user's level of focus as they manipulate the movement of a virtual hand in a 3D animation approach. Compared to the robotic-based system, this one is determined to be more cost-effective, entertaining, and user-friendly. Additionally, it can be utilized to treat patients with trauma-related neurological problems.

Renormalizing the topology of the brain's functional networks in children with ADHD was the subject of another trial using a BCI-based intervention [58]. The researchers investigated the alterations in the structure of brain functional networks using the resting-state fMRI technique. Following training, the intervention group's inattention symptoms were much lower than those of the non-intervention group.

A pilot study employing a specially designed neurofeedback video game, *Harvest Challenge*, was presented by Blando'n et al. [59]. The video game measures players' attention levels using a cheap brain–computer interface (BCI), which is then used as an input control.

An intervention consisting of two sessions was conducted with seven children with ADHD to increase their sustained attention levels. The findings showed that participants' sustained attention levels (as determined by game measures) had improved, and their resting alpha and beta band power values were higher than their delta and theta band power values.

The brain–computer interface game *Orbit* was created by Arrambide et al. [60] to see if children with ADHD would be more receptive to neurofeedback treatment. The player influences the game by focusing and paying attention, which might help a child develop their attention span. However, only one player is in the game; therefore, working with other players does not encourage social drive. It has been demonstrated that using cooperative multiplayer games in the treatment of children with ADHD is suitable for long-term use. The study demonstrated that a combination of social support from a non-playable character (NPC) should be created at the beginning of the therapy and played with another youngster later [60].

Alchalabi et al. [61] examined how machine learning can be used to determine a patient's attention level while training and strengthening their attentional skills through a demanding EEG-controlled game called *FOCUS*. Using the Unity game engine, *FOCUS* imitates a few current clinical and rehabilitation treatments. By concentrating and using mental commands, the player must maneuver an avatar to gather as many cubical pickups as possible in the shortest time. According to the findings, the game's scenarios improved the attention span of ADHD children.

Accordingly, a BCI training method for children's attention improvement was proposed in a study by Chang et al. [62]. Three different game types corresponding to the alerting, orienting, and executive training networks were included in the game, which was developed using attention network theory. Depending on their unique circumstances, users can select the appropriate game style and degree of difficulty for focused training. Completing the attention network-related game training assignments regularly helps to increase attention. The findings showed that the training system may successfully produce an engaging, motivating, and seamless training environment while assisting participants in improving their attentional performance (Table 1) (Figure 3).

Table 1. Brain–computer interface (BCI)/neurofeedback games for ADHD.

Authors	Game Name	Year	Participants	Targeted Areas of Improvement	Outcome Measure
Lim et al. [56]	*Cogoland*	2023	20 children with ADHD aged 6–12	Attention ability	ADHD Rating Scale (ADHD-RS), parents and clinician questionnaires for inattention and hyperactive–impulsive symptoms on a 4-point Likert scale (1 = never or rarely, 4 = very often), Child Behavior Checklist (CBCL)
Jiang et al. [57]	_____	2011	Children with ADHD	Attention ability	ADHD Rating Scale, Child Behavior Checklist (CBCL)

Table 1. *Cont.*

Authors	Game Name	Year	Participants	Targeted Areas of Improvement	Outcome Measure
Qian et al. [58]	_____	2018	66 boys with ADHD, either combined or inattentive subtypes aged 6–12	Attention ability	Resting-state functional magnetic resonance imaging method, DHD-RS clinician inattention scores, Child Behavior Checklist
Blandón et al. [59]	*Harvest Challenge*	2016	7 children with ADHD	Attention ability	Record of EEG signals from users before, during, and after the gameplay
Arrambide et al. [60]	*Orbit*	2019	five neuropsychologists	Attention ability	Open-ended qualitative group interview, after the game
Alchalabi et al. [61]	*FOCUS*	2019	5 healthy subjects (males, age range 19–26), 4 ADHD subjects: 2 males (18 and 23 years old), and 2 females (21 and 22 years old)	Attention ability	Record of EEG signals from users before, during and after the gameplay
Chang et al. [62]	_____	2022	5 healthy subjects, age 4–6	Attention ability	EEG data, game experience questionnaire (GEQ), Conners child behavior scale (parent edition), Schulte grid test

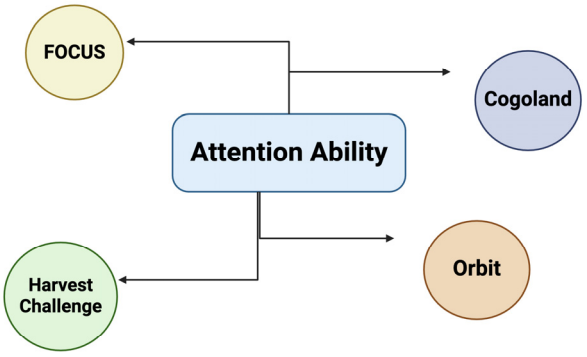

Figure 3. BCI serious games for attention improvement.

4.2. PC-Based Serious Games

Several computer-based exercises have been created in recent years to improve the efficacy of treating attention deficit hyperactivity disorder (ADHD). Prins et al. created a computerized executive functioning training program with game components to improve self-control [63]. The computerized training of three EFs—cognitive flexibility, inhibition, and visuospatial working memory—in a vast, game-like environment is called Braingame Brian. Forty youngsters (8–12 years old) with a clinical diagnosis of ADHD were randomized to either the waiting condition (n = 22) or Braingame Brian (n = 18). The children in the EF training condition demonstrated a significant improvement in ADHD behaviors

(inattention and hyperactive–impulsivity subscales of the Disruptive Behavior Problems Scale) [64], as well as parent-rated EFs (BRIEF total score) [65].

Children aged 8 to 12 with ADHD can benefit from training and assessing impulsivity, inhibition control, and cognitive flexibility using the SG *Antonyms* described in the Crepaldi et al. [66] study. In *Antonyms*, a superhero named Atansyon is personified by the player and tasked with rescuing a kingdom on the other side of the planet. Atansyon must go through four scenarios—Woodlands, River Crossing, Training School, and Central Building—each represented by a mini-game to rid the planet of adversaries. The results of an assessment of an early iteration of the serious game lend credence to the idea that *Antonyms* could be used in rehabilitation programs to help children control their impulsive behavior.

The serious game *Plan-It Commander* was created by Bul et al. [67] with children with ADHD aged 8 to 12 in mind. The serious game's therapeutic behavioral learning aims were to encourage the use of methods in key areas of day-to-day functioning, such as prosocial skills, planning/organization, and time management. According to the usability data, parents and children with ADHD responded favorably to this game intervention. They both expressed their satisfaction with the initial prototype and said they would suggest the game to other parents of children with ADHD.

The three mini-games in another game, *Adventurous Dreaming Highflying Dragon: A Full Body Game for Children with ADHD*, are designed to address several underlying problems that children with ADHD encounter [68]. The first mini-game encourages learning through focused attention by having players practice paying attention to particular visual cues. The second mini-game tries to develop hand–eye coordination and gross and fine motor skills. The third mini-game tests the ability to remain motionless in a specific position. The main objective of this game, which requires participants to use their entire body, is to increase goal-setting and commitment.

The multimodal 3D computer serious game *ADDventurous Rhythmical Planet*, developed by Giannakari et al. [69], uses rhythm and music to aid children with attention deficit hyperactivity disorder (ADHD). More precisely, its goal is to help children with ADHD work with other children in fun while using music to engage them and help them develop their social, communicative, cognitive, academic, emotional, and behavioral skills. The effectiveness of the game in improving children's social skills and teamwork was confirmed by the reported pilot study (Table 2) (Figure 4).

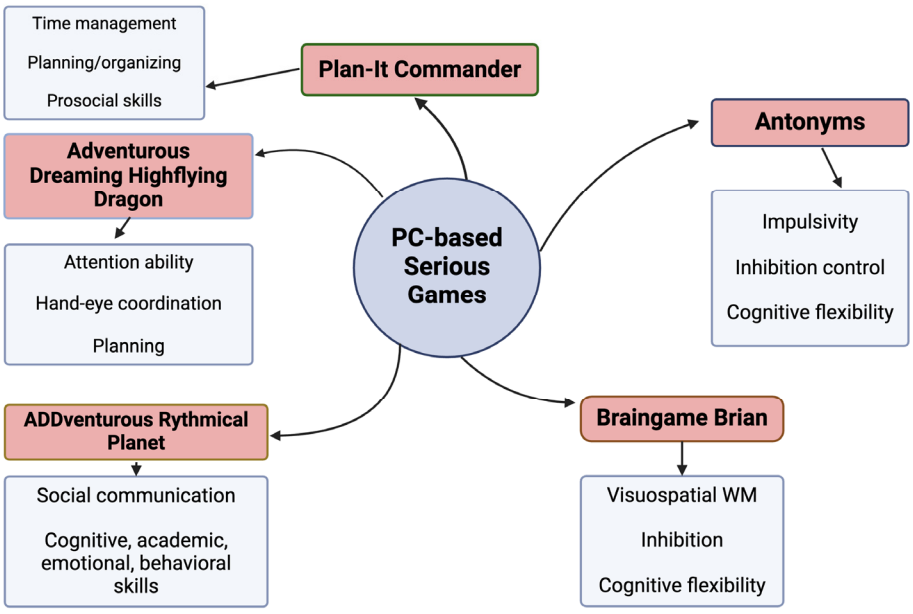

Figure 4. PC-based serious games and areas of improvement.

Table 2. PC-based serious games for ADHD.

Authors	Game Name	Year	Participants	Targeted Areas of Improvement	Outcome Measure
Prins et al. [63]	*Braingame Brian*	2013	40 clinically diagnosed children with ADHD (8–12 years old)	Visuospatial WM, inhibition, cognitive flexibility	Parent-rated EFs (BRIEF total score), ADHD behaviors (Inattention and Hyperactive-impulsivity subscales of the Disruptive Behavior Problems Scale)
Crepaldi et al. [66]	*Antonyms*	2020	30 typically developing children (16 boys; age: M = 9.30 years, SD = 0.87), 16 ADHD boys aged 8–11 (M = 9.19 years; SD = 0.91	Impulsivity, inhibition control, cognitive flexibility	Ad hoc questionnaire, scores in Antonyms tasks, Conners Continuous Performance Test II (CPT II v. 5)
Bul et al. [67]	*Plan-It Commander*	2015	42 clinically referred children with a primary diagnosis of ADHD, age ranged from 8 to 11 years	Time management, planning/organizing, prosocial skills	Parent and participant questionnaires
Hashemian and Gotsis [68]	*Adventurous Dreaming Highflying Dragon: A Full Body Game for Children with ADHD*	2013	73 clinically diagnosed children with ADHD (6–13 years old)	Attention ability, hand–eye coordination, planning	Attention tests, teacher questionnaires
Giannakari et al. [69]	*ADDventurous Rhythmical Planet*	2019	Four children (8–12 years old), two of them were diagnosed with ADHD. Four educators, specialized in special education	Social, communication, cognitive, academic, emotional, behavioral skills	Two types of questionnaires, one targeting children of 8–12 years old and the other targeting expert educators

4.3. Mobile/Tablet Serious Games

Based on previous research on strategies for retaining attention and engaging children with ADHD, Said et al. [70] created the mobile video game *Mathefunic*, They discuss how rewards may be used to encourage youngsters to participate in video games and how they can be used to regulate the behavior of children with ADHD. Frequent rewards should be given, and those who fail to accomplish tasks or follow instructions should not receive them.

According to a study by Wrońska et al. [71], children with ADHD can benefit from a new interactive tool. The application enhances children's reading comprehension abilities using a game-based learning methodology. The author designed a game for the iPad, *LyC: Lectura y Comprensión*, which translates to "reading and comprehension", based on methods employed in Serious Games for Health, by transforming paper-based exercises that have been used up to this point in ADHD therapy. According to participant feedback, the game is easy to use. It is a valuable tool that may assist children with attention deficit disorder in enhancing their reading comprehension abilities and in turn their academic achievement.

The app Say-it and Learn was created by Butt et al. [72] to encourage ADHD children and keep them engaged in their educational tasks in a welcoming and engaging setting. According to preliminary findings, the software was helpful, captivating, and engaging, enhancing youngsters with ADHD's capacity for learning. Compared to conventional education techniques, the produced app demonstrated the children's level of engagement according to observations, guardians, and teachers. Additionally, they confirm that Say-it and Learn is an engaging app that will help all children with ADHD with their schoolwork.

The "e-tutor system" [73] is another learning program designed for children with ADHD that teaches language, math, and basic hygiene. The results of this gamified system, created for Android, indicated that it may be used as an additional tool to help students succeed in their studies and is appropriate for special education services.

Tobias et al. [74] discuss their initial attempt at testing *ChillFish* with children who have ADHD in another paper. The toddler breathes through an actual LEGO fish controller to play the soothing biofeedback game *ChillFish*. According to their findings, engaging in *ChillFish* offers a relaxing sensation akin to a standard breathing technique. Since the gameplay of *ChillFish* supports and encourages the player to undertake a breathing exercise because of the starfish's strategic placement, it is not surprising that the game may offer a calming experience for both adults and children. Through greater activation of the parasympathetic nervous system, which has a soothing effect, breathing exercises impact the autonomic nervous system, as we know from the research [75,76]. After an angry outburst or before bed, this experience is essential for the children.

The effects of playing *Boogies Academy* and *Cuibrain* on attentional factors in a sample of people with learning challenges, including ADHD and specific learning disorders (SLDs), were examined in a study by Redondo et al. [77]. In order to examine and compare the attentional profiles of the two groups (the experimental and control groups), a quasi-experimental study was conducted utilizing performance-based and observation measures (questionnaires). The findings demonstrated that children with ADHD performed noticeably better in attention, with an overall rise in focus and response accuracy during the performance.

The effectiveness of the emotional therapeutic video game *EmoGalaxy* in children with ADHD was examined in a study by Hakimirad et al. [78]. The game's architecture requires the player to move between four different planets. Happiness, sadness, fear, and wrath are the primary feelings that each planet represents. A player can start a game anywhere on Earth. Emotion recognition, emotion expression, and emotion control are the three areas of emotion capacities that the game is intended to address. The findings demonstrate how well video games can enhance problem-solving abilities, creativity, flexibility, working memory and emotion identification.

A player of *Evo Project/EndeavorRx*, another serious game, must make snap judgments, which compels the brain to focus and block off distractions [79]. Such activities include maneuvering a spacecraft across a canyon, where players must ignore the other fish and choose one color from those that show on the screen. As the game progresses, the player's abilities are assessed, and the game's difficulty is adjusted accordingly. According to the evaluation results, this game can assist children become more focused and advance their learning capabilities (Table 3) (Figure 5).

Table 3. Mobile/tablet serious games for ADHD.

Authors	Game/App Name	Year	Participants	Targeted Areas of Improvement	Outcome Measure
Said et al. [70]	*Mathefunic*	2020	ADHD Children (8–12 years old)	Attention ability	Usability questionnaire for participants

Table 3. *Cont.*

Authors	Game/App Name	Year	Participants	Targeted Areas of Improvement	Outcome Measure
Wrońska et al. [71]	*LyC: Lectura y Comprensión*	2015	6 typically developing children (8–12 years old)	Reading comprehension skills	Participants questionnaires using a Likert scale ranging from 1—strongly disagree‖ to 5—strongly agree‖
Butt et al. [72]	Say-it and Learn	2020	5 ADHD children having age (m = 6.4) years, parents	Learning ability	Student, parent and caregiver questionnaires
Supangan et al. [73]	e-tutor system	2019	ADHD children (8–12 years old)	Learning ability	Teachers questionnaires
Tobias et al. [74]	*Chillfish*	2016	12 children with ADHD between 8 and 13 years old	Emotional control	Heart rate monitor for heart rate variability (HRV), electrodermal activity (EDA) sensors
Redondo et al. [77]	*Boogies Academy Cuibrain*	2019	44 students (age range = 6–16 years; experimental group = 24; control group = 20) with attention deficit hyperactivity disorder (ADHD) and specific learning disorder (SLD)	Attention ability Learning ability	Performance measures (D2 Attention Test) and observation measures (EDAH scale completed by families)
Hakimirad et al. [78]	*EmoGalaxy*	2019	20 ADHD boys (7 to 12 years old)	Emotion recognition, emotion expression, emotion regulation	Gersham and Eliot's social skills test
Canady [79]	*Evo Project/EndeavorRx*	2020	348 ADHD children (8 to 12 years old))	Attention ability Learning ability	Vanderbilt ADHD Diagnostic Parent Rating Scale

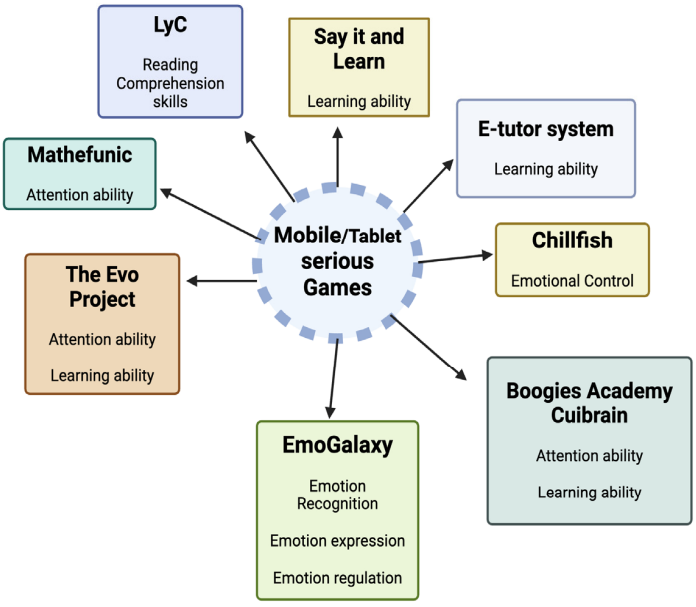

Figure 5. Mobile/tablet serious games and areas of improvement.

4.4. Virtual Reality Serious Games

New technologies like virtual reality and serious video games can be employed as therapeutic tools to treat ADHD. A virtual reality serious video game called *The Secret Trail of Moon* (TSTM) was created by Rodrigo-Yanguas et al. [80] to educate cognitive skills related to executive dysfunction and core symptoms of ADHD. TSTM was created for educational objectives rather than for amusement. Additionally, it introduces chess and teaches individuals unfamiliar with the game's fundamentals through gamification [81,82]. Of the experts who participated in the study, 91% said they would utilize a serious video game like TSTM as an educational and rehabilitation tool.

Ou et al. [83] created the *HTC VIVE* (HTC, Taiwan) virtual reality game console as part of a three-month training program for children with ADHD. They compared the children's attention, cognitive function, abstract reasoning, and complicated information processing before and after the program. According to the findings, these children performed better in attention, impulse control, and oppositional defiance when this VR serious game was used as a rehabilitation aid.

With a focus on addressing specific symptoms of ADHD and academic functioning, a study by Noof et al. [84] examined the effect of VR therapies on enhancing the learning outcomes of children with ADHD who are between the ages of 5 and 10. According to the findings, most participants (70.0%) had a moderate attention span, meaning they could stay engaged with the VR intervention for a respectable amount of time, which was beneficial for learning and interacting with others in the virtual setting. With 70.0% of individuals displaying pleasant facial expressions and 54.5% displaying participatory body language, many participants demonstrated positive emotional responses, suggesting they were at ease and enjoying the VR environment.

Another study by Tarng et al. [85] created two serious VR games, *Electrical Maze* and *Matching Shape or Color*, to examine how well virtual reality (VR) can train elementary school pupils' attention. In a training experiment, VR instruction was given to the experimental group, whereas computerized attention process instruction (APT) was given to the control group. The statistical analysis showed that VR training improved participants' attention while lowering their cognitive load and learning anxiety more than the APT. It was therefore a helpful tool for attention training in elementary classrooms (Table 4) (Figure 6).

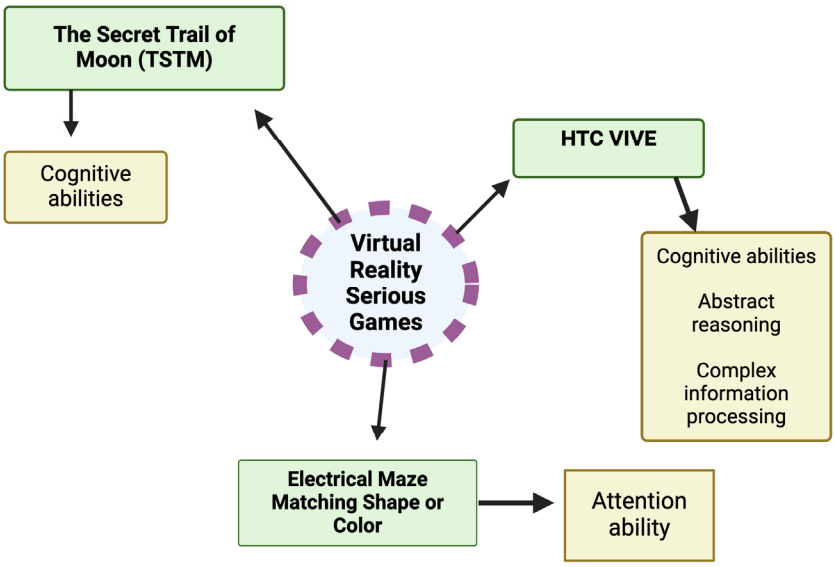

Figure 6. Virtual reality serious games and areas of improvement.

Table 4. Serious Games based on Virtual Reality for ADHD.

Authors	Game Name	Year	Participants	Targeted Areas of Improvement	Outcome Measure
Rodrigo-Yanguas et al. [80]	*The Secret Trail of Moon* (TSTM)	2021	37 ADHD children and adolescents (12–22 years old), 56 mental health and education professionals	Cognitive abilities	Ad hoc questionnaire for patients
Ou et al. [83]	*HTC VIVE*	2020	3 ADHD children aged 8–12 years	Cognitive abilities, abstract reasoning, complex information processing	Interviews with participants and their parents, Test of Nonverbal Intelligence (fourth edition; TONI-4), Attention Test for Elementary School Children (ATESC), Wisconsin Card Sorting Test (WCST), parent form of the Chinese version of the revised Swanson, Nolan, and Pelham (SNAP-IV) questionnaire
Noof et al. [84]	_____	2024	20 ADHD children (5–10 years old)	Learning ability	Interviews and tests for participants, observation of behavior during VR gameplay
Tarng et al. [85]	*Electrical Maze Matching Shape or Color*	2022	66 typically developing children (8–10 years old)	Attention ability	Attention scale for elementary school children

4.5. Augmented Reality Serious Games

Creating serious games using cutting-edge technology like augmented reality (AR) that emphasize cognitive–behavioral therapy for children with ADHD who are of school age is one of the biggest challenges. The BRAVO project, which intends to create an immersive therapeutic game context to support an alternative modality for treating ADHD, was detailed by Barba et al. [86]. BRAVO is built on a cutting-edge ICT system to strengthen the bond between adolescent patients and treatments. In order to detect and save the patient's emotional states and enable real-time game adaption, BRAVO's gaming environment includes a few serious games that use wearable technology and virtual and augmented reality gadgets. Even compared to traditional therapy, the initial findings already demonstrate the vast potential of serious games in drawing in young patients.

By assessing the efficacy of an augmented reality serious game (ARSG) named *ATHYNOS*, Avila-Pesantez et al. [87] wanted to demonstrate the positive outcomes of improving attention in children with ADHD. In order to stimulate the learning environment, a natural user interface that was based on body movements was also taken into consideration. Cognitive abilities, including motivation, feedback, problem-solving, hand–eye coordination, and interactivity, are all part of *ATHYNOS*, which enhances selective and focused attention. According to the descriptive statistical analysis, individuals who played *ATHYNOS* throughout the eight sessions improved their everyday functioning in social skills and time management. Consequently, their level of concentration improved.

Tosto et al. [88] created the AHA (ADHD—Augmented) project to enhance an existing literacy program with augmented reality capabilities and apply an evidence-based intervention to increase the reading and spelling skills of ADHD children. Based on the project's initial results, the AHA initiative successfully integrated augmented reality (AR) into an existing online literacy program incorporating several distinct technologies and facilitating interactive learning materials, services, evaluation, and feedback.

Gabele et al. [89] presented the concept and implementation of a multi-user AR game prototype called *AR Sandbox* in their paper. It incorporates elements of BCI training, eye tracking, and sand as a haptic component and can be utilized as an extension for the long-term therapy of children with ADHD. Qualitative explorative expert research demonstrated that such a system is appropriate for use in therapy for children with ADHD. It may be used to support therapy from the start.

Gremlins in My Mirror is an inclusive AR-enriched video game created by Tobar-Muñoz et al. [90] to teach logical math skills. This game is founded on a set of design ideas that were put forth in light of AR affordances and ADHD treatment considerations. According to the findings and comments from the teaching staff, the digital game succeeds in involving every child in the educational process. Every student met the game's objectives and experienced high motivation during the learning process, which benefits children with ADHD.

Another study by Arpaia et al. [91] suggests a wearable brain–computer interface and augmented reality device for remotely controlling a robot to help children with attention-deficit hyperactivity disorder (ADHD) recover. An inexperienced user can control a robot by blinking and focusing on flickering stimuli. Training is not necessary for the feature extraction algorithm. Following receipt of the commands, the robot provides the user with both visual and aural feedback. The optical see-through augmented reality technology enables simultaneous viewing of visual stimuli and the robot's movements. Four ADHD children, ages 6 to 8, responded favorably to tests of their attentional function and device acceptance (Table 5) (Figure 7).

Table 5. Serious games based on augmented reality for ADHD.

Authors	Game/Project Name	Year	Participants	Targeted Areas of Improvement	Outcome Measure
Barba et al. [86]	BRAVO	2019	60 ADHD children (3–12 years old)	Social skills	EEG helmet and bracelet with reference to biofeedback data, gaming scores
Avila-Pesantez et al. [87]	*ATHYNOS*	2018	11 children diagnosed with ADHD, aged 7–10 years old	Attention ability, hand–eye coordination motivation, interactivity, problem-solving, time management	Therapist's observations
Tosto et al. [88]	AHA	2021	117 students (aged 8–9 to 11–12 years); 2 with a diagnosis of ADHD	Reading and spelling abilities	Neale Analysis of Reading Ability (NARA-II), the Vernon Graded Word Spelling Test, WWL questionnaires

Table 5. *Cont.*

Authors	Game/Project Name	Year	Participants	Targeted Areas of Improvement	Outcome Measure
Gabele et al. [89]	*AR Sandbox*	2019	Seven domain experts aged 21–50 years (interaction designers, computer scientist, neuropsychologist)	Social skills	Interview with participants
Tobar-Muñoz et al. [90]	*Gremlins in My Mirror*	2014	20 children aged 8–12 years (4 typical, 3 with ADHD, 1 with autism, 7 with mental retardation, 1 with Asperger syndrome, 1 with microcephaly, 1 with Down syndrome, 2 with deafness)	Logical Math Skills Learning	Questionnaires for participants
Arpaia et al. [91]	_____	2020	4 ADHD children between 6 and 8 years old	Cognitive abilities	Tests regarding attentional function of participants and device acceptance

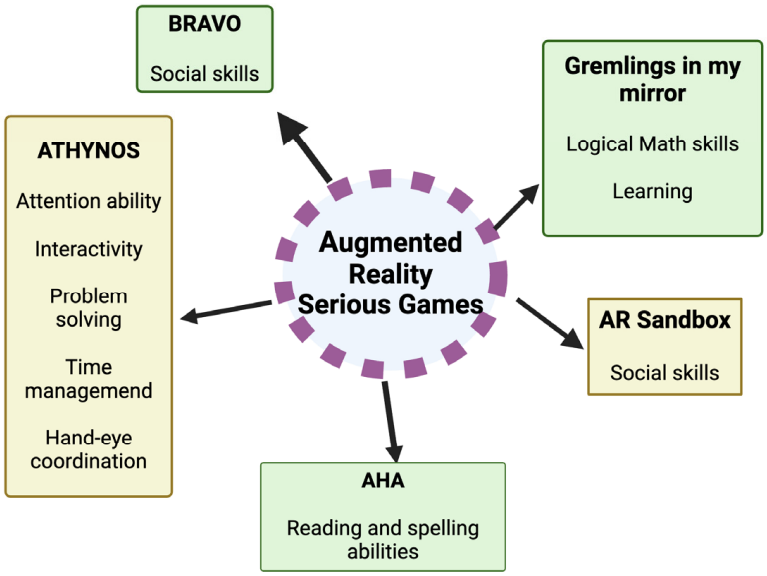

Figure 7. Augmented reality serious games and areas of improvement.

5. Discussion

While several systematic or narrative reviews have been conducted regarding the use of serious games in the treatment of ADHD, there is a need for additional research. A systematic review conducted by Zheng et al. [8] explored the crucial role of serious games in diagnosing and treating ADHD, recognizing them as a fundamental resource for managing the condition and offering a promising perspective for addressing the disorder. However, the limited approach to more complex technologies, such as VR, AR, and BCI, makes it necessary to enrich the existing research. Another study focused only on intervention in specific cognitive symptoms, such as attention, without delving into ADHD and without covering other aspects of the daily life and emotional development of these children [92]. In a systematic review by Valentine et al. [93] regarding the use of new technologies as a

means of intervention in ADHD, even though the studies showed some positive results, such as improvement in attention and concentration, the use of serious gaming for ADHD treatment was reported in few studies. Therefore, a new review is necessary based on the gaps and limitations of previous research.

This systematic review's purpose was to determine whether serious games using various technologies are beneficial for children and adolescents with ADHD and to advance evidence-based practice. According to our review, numerous trials of serious game-based multi-technological interventions have been developed over the years to address the needs and issues of children with ADHD. These solutions support various needs (i.e., diagnosing vs. treating), aim to address various goals (i.e., working memory, impulsivity, inattention, executive functions, emotion regulation), and use a wide range of technologies, including video games [94], PC [62], mobile devices [11], AR [13], VR [12], and BCI/neurofeedback [10], sometimes even in combination.

The relationship between technology, learning, motivation, and a sense of pleasure makes serious games (SGs) proper instruments in several rehabilitation domains [43]. Many educators, psychologists, and teachers use SGs to help individuals learn, develop, and adapt to change because of their exceptional capacity to draw in, keep, and inspire players [44]. Additionally, SGs, which have been suggested as rehabilitation tools, can improve the efficacy of the therapeutic process or offer more responsive treatments [41,42]. Moreover, SGs have demonstrated efficacy in enhancing executive functioning [95], reading speed [46,47], motivation, treatment compliance [96], planning and organizing abilities, and generally the enhancement of damaged skills [54]. Even with well-established, evidence-based psychological therapies [95,96], SGs can help patients with a variety of illnesses [37–40], as well as those with impulse-related disorders, dysfunctional emotional regulatory processes, and disinhibited personality traits [55]. These are some of the most challenging core symptoms to treat. Lastly, the effectiveness of SGs in improving positive attitudes [48], developing problem-solving techniques, and changing abnormal behaviors, including those in children with attention deficit hyperactivity disorder (ADHD) [43], has been substantiated by several studies, something that is also highlighted in recent studies using AI gamified chatbots [97]. SGs may also help patients with ADHD strengthen their visuospatial attention abilities [62].

Early intervention techniques are necessary for treating ADHD in order to support children in all areas of executive functions where they are lacking, including working memory, inhibitory control, suppression of inappropriate behaviors, and switching between activities [91–94]. The relationship between metacognition and executive skills is highlighted by Drigas and Mitsea [24–26], who also stress metacognition's critical role in their functioning. More precisely, cognitive deficits in flexibility, problem-solving, and decision-making may be made up for by an increased metacognitive capacity. It is accomplished by self-evaluation, self-observation of the cognitive mechanism, and the necessary training to redirect attention to data that directs the best action.

Children with ADHD are typically driven by the need to keep the experience at a "minimum waiting level", grow bored easily, and prefer instant gratification [4–6]. Therefore, it is critical to maintain their interest at all times. Gamification, or the use of game features, can help with this [44]. By keeping the child attentive and involved during the entire process, SGs can improve motivation and treatment efficacy [9]. To avoid monotony and maintain motivation, the same scenes and activities might be replayed in new ways [32].

According to several studies, SGs may help children, especially those with ADHD, improve their executive functions and attention skills [34]. Examples include the computerized training programs *Adventurous Dreaming Highflying Dragon: A Full Body Game for Children with ADHD* [68], *Antonyms* [66], *Harvest Challenge*, a BCI video game that measures brain signals [59], *Cogoland* [56], *Plan-it Commander* [67], and *FOCUS* [61]. According to

other research, SGs (like *Orbit* [60]) may help treat children with ADHD regarding their cognitive function, reward systems, and sense of time. Neurofeedback systems, which are a component of several SGs, have been demonstrated to enhance executive control in ADHD participants when used in conjunction with medication [57]. Other SGs employ electroencephalogram (EEG) feedback to develop attentional skills [58]. Prins et al. examined the efficacy of the brain–computer interface *Braingame Brian* [62] in treating ADHD in pilot research. They discovered that it improved the ability to manage hyperactive–impulsive and inattentive symptoms.

Furthermore, *The Secret Track of the Moon* uses virtual reality to train individuals with ADHD cognitively and provides a realistic chess-based game experience [80]. This game offers a distinctive and captivating method of cognitive function training by fusing chess's strategic components with virtual reality's immersive qualities. Players can hone their critical thinking, problem-solving, and planning skills. In addition to encouraging cooperation between children with ADHD and other players, *ADDventurous Rhythmical Planet* uses musical rhythm to enhance attention and curb impulses [69]. This game's use of rhythm and music helps children improve their timing and self-control, and its cooperative gameplay promotes cooperation and social connection. Last but not least, *ChillFish*'s breathing exercises, which use LEGO respiratory sensors to promote emotional regulation and reduce stress, rank among the most creative treatment approaches for children with ADHD [74]. These activities teach children how to control their emotions and stress, which is especially helpful for children with ADHD.

All of these various technological approaches have their advantages when it comes to helping children with ADHD with their cognitive, metacognitive, and socioemotional difficulties, but they also have drawbacks. In order to address particular cognitive skills like working memory, attention, and problem-solving, PC-based serious games can use intricate scenarios and multi-layered gameplay [62,64,66,69]. However, their restricted mobility can make them useful only in specific settings, such as residences or therapy facilities [64], and they might not be as captivating for children used to mobile gaming [67,68]. Mobile/tablet-based serious games are generally accessible, affordable, and enable involvement at any time and location, which increases usage [70,79]. However, smaller screens might not offer the same level of immersion as PC-based games, and games with limited processing power may be less complicated [73,75].

Virtual reality (VR) serious games can greatly interest children and enhance their executive functioning and attention spans because of their high degrees of immersion and interaction [82,83]. They also provide a dynamic, regulated environment that mimics real-world difficulties. However, they have several significant drawbacks, including the expensive cost of the hardware and particular setup challenges [79]. Augmented reality (AR) serious games are fascinating and informative because they combine digital and real-world interactions [87,90]. Additionally, they promote hand–eye coordination and physical activity through intuitive user interfaces.

Nevertheless, such games necessitate more gear, such as AR glasses or related gadgets, which raises the price [85]. The last example is brain–computer interface (BCI)/neurofeedback games, which directly track brain activity to provide real-time feedback and targeted attention and improve self-regulation [56,60]. By fusing therapeutic intervention with gameplay, these games show promise as a long-term improvement tool [56]. Nevertheless, they are also expensive and necessitate specific tools, such as EEG headsets [57]. Furthermore, because of the intricacy of the setup and the possibility of discomfort during sessions, it might not be appropriate for every child [61].

Limitations and Suggestions for Future Research

Some limitations should be noted despite our study's comprehensive systematic evaluation and significant findings. Comparing outcomes is challenging because the examined research in particular employs a variety of technological approaches (such as VR, AR, and BCI) and evaluation techniques. Furthermore, the reliability and validity of the results may be impacted by the small samples in many of the included studies. Since most research assesses the immediate consequences of serious game use, another constraint is the requirement for long-term evaluations. On the other hand, it is unclear how these games affect the long-term growth of executive functions and metacognitive abilities in ADHD. Another factor affecting the outcomes is the inclusion of heterogeneous populations in some research. This can make it more difficult to evaluate the results for children with ADHD because some studies include populations with different conditions (such as autism or learning difficulties).

Additionally, a thorough assessment of the negative impacts of serious games is necessary, because despite their acknowledged benefits, no study addresses potential drawbacks, such as weariness or frustration from extended use. Last but not least, it is critical to consider certain technological constraints, since the cost and accessibility of cutting-edge technology, like brain–computer interfaces (BCIs), may restrict their use in larger populations. When evaluating the findings of this study and planning subsequent research, these limitations should be considered. More research should investigate these technologies' efficacy over an extended period and in various contexts.

6. Conclusions

The results of the current systematic review study show how serious games that use technology, particularly those aided by computers, mobile devices, tablets, virtual reality, and augmented reality, can help children with ADHD develop their executive functions as well as their metacognitive and emotional competencies. Because they are easier to use, mobile games might be better for younger children, but PC-based games might be more appropriate for teenagers who can perform more complex tasks. While BCI games may be limited to therapeutic settings because of their specialist nature, VR and AR games could be included in therapy sessions or school settings to increase engagement. The findings showed notable gains in various competencies, such as working memory, learning, attention, self- and emotional awareness, inhibitory control, emotional regulation, and adaptability. Children with ADHD were able to finish the training programs more easily thanks to the safe, adaptable, interactive, and entertaining training environments that serious games provide. Our interpretation of the data leads us to conclude that serious games can work together to optimize the training experience, particularly when various technologies are involved. For future research on technologically aided therapies aimed at improving the skills of children with attention deficit hyperactivity disorder, this study might offer encouraging results. Lastly, several potential avenues for further study on this subject are proposed. In order to ascertain their viability and potential for incorporation into conventional treatment procedures, future research could examine the long-term impacts of serious games via digital technologies on symptoms of ADHD. New game mechanics and technological advancements that increase the therapeutic advantages of serious games could also be the subject of future research. The field can advance and provide creative and practical approaches to managing ADHD by tackling these issues.

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