

# Enhancing Attention Regulation in ADHD Through Serious Games: A Narrative Review of Neurocognitive Mechanisms and Clinical Implications

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## ABSTRACT

Attention-Deficit/Hyperactivity Disorder (ADHD) is a common neurodevelopmental condition characterized by persistent patterns of inattention, hyperactivity, and impulsivity. Among these symptoms, impairments in attention regulation represent one of the most significant cognitive challenges affecting academic performance and daily functioning in children with ADHD. Recent advances in digital technology have introduced serious games as innovative tools for cognitive training and behavioral intervention. This literature review aims to examine current evidence regarding the role of serious games in improving attention regulation among children with ADHD. A narrative review approach was used to analyze peer-reviewed studies published within the past ten years that investigated serious game interventions targeting attentional processes. The reviewed literature suggests that serious games may enhance sustained attention and attentional control through adaptive gameplay, multisensory feedback, and reward-based reinforcement mechanisms. These findings indicate that serious games may serve as promising complementary tools for supporting attention regulation and cognitive development in children with ADHD.

**Keywords:** serious games; ADHD; attention regulation; cognitive training; psychological wellbeing

## INTRODUCTION

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most prevalent neurodevelopmental conditions affecting children and adolescents, characterized by persistent patterns of inattention, hyperactivity, and impulsivity that interfere with academic performance, social functioning, and daily activities. With global prevalence estimates ranging from 5–7% among school-aged children, ADHD represents a substantial burden within child and adolescent mental health systems [1]. Among its core features, difficulties in attention regulation are consistently identified as particularly impairing, as they directly affect a child's ability to sustain focus, manage competing stimuli, and engage in goal-directed behaviour. Attention regulation is a central component of executive functioning, encompassing sustained attention, selective attention, and inhibitory control. These processes are supported by interconnected neural systems, including fronto-striatal and fronto-parietal networks, with the dorsolateral prefrontal cortex (DLPFC) playing a key role in cognitive control and behavioural regulation [2]. In children with ADHD, structural and functional alterations within these networks, such as reduced

grey matter volume and disrupted connectivity, have been associated with impairments in attention, emotional regulation, and complex task execution. Dysregulation within dopaminergic pathways further contributes to difficulties in reward processing and motivation, which can intensify attentional challenges and reduce persistence in effortful tasks [3].

Current treatment approaches for ADHD typically combine pharmacological and behavioural strategies. Stimulant medications and psychosocial interventions are effective in reducing core symptoms; however, they do not always fully address underlying cognitive deficits, particularly those related to attention regulation and executive functioning. Practical challenges, including treatment adherence, accessibility, and sustained engagement, also limit their impact in real-world settings. These considerations highlight the need for complementary approaches that are both developmentally appropriate and capable of maintaining children's active participation. Digital interventions, particularly serious games, have gained increasing attention as potential tools to

address these gaps. Unlike conventional video games, serious games are intentionally designed with therapeutic or educational objectives, embedding cognitive training tasks within interactive and engaging environments [4]. Through features such as adaptive difficulty, multisensory feedback, and reward-based reinforcement, these interventions encourage repeated practice of attentional skills while sustaining motivation. This combination is particularly relevant for children with ADHD, who often struggle with sustained engagement in traditional training formats.

From a neurocognitive perspective, serious games may support attention regulation by engaging neural circuits associated with executive functioning and promoting experience-dependent neuroplasticity. Adaptive challenges help maintain an optimal level of cognitive load, while immediate feedback and reward mechanisms reinforce task-related behaviour and persistence. Empirical findings increasingly support this perspective. A synthesis of recent studies suggests that a substantial proportion of serious game interventions are associated with improvements in attention and executive functioning, alongside reductions in hyperactivity-impulsivity symptoms [5]. Experimental and prototype-based studies further report gain in task initiation, organizational skills, and measurable changes in neural activation following intervention [6,7].

Despite these encouraging results, several challenges remain. The effectiveness of serious games appears to vary depending on individual characteristics, intervention design, and implementation context. Concerns have also been raised regarding overstimulation, the need for supervision, and the sustainability of engagement over time. Moreover, evidence regarding long-term outcomes and the transfer of cognitive improvements to everyday functioning is still limited, indicating the need for further investigation. Emerging research also highlights that ADHD extends beyond attentional deficits to include difficulties in emotional regulation, which can influence both individual functioning and family dynamics. A community-based study conducted in Surabaya found that ADHD symptoms were associated with increased emotional lability and negativity, with poorer emotional regulation linked to greater family dysfunction [8]. This broader perspective suggests that interventions targeting attention regulation may also have indirect effects on emotional and behavioural processes, given the shared underlying mechanisms of executive functioning.

Taken together, these considerations point to the potential role of serious games as part of a more comprehensive, biopsychosocial approach to ADHD management. By combining cognitive training with engaging and adaptive design, serious games may offer a practical means of addressing attentional deficits while supporting motivation and participation. Therefore, this literature review aims to synthesize current evidence on the role of serious

games in improving attention regulation among children with ADHD, with particular emphasis on underlying neurocognitive mechanisms and clinical implications. Through the integration of recent empirical findings and theoretical perspectives, this review seeks to clarify the potential contribution of serious games as an adjunctive strategy in the management of ADHD.

## METHODS

### Review Design

This study employed a narrative literature review to synthesize current research on the use of serious games as digital interventions for improving attention regulation in children with Attention-Deficit/Hyperactivity Disorder (ADHD). The review aimed to examine existing evidence regarding the design characteristics, mechanisms, and cognitive outcomes associated with game-based interventions targeting attentional processes. Narrative review methodology was selected to allow a comprehensive exploration of interdisciplinary literature from fields including psychiatry, neuroscience, psychology, and digital health technologies.

### Literature Search Strategy

A comprehensive literature search was conducted using several academic databases, including PubMed, Scopus, and Google Scholar, to identify relevant peer-reviewed articles. The search focused on studies published between 2014 and 2024 to ensure that recent developments in digital therapeutic technologies were included. The search strategy used combinations of keywords and Boolean operators, including:

- Attention-Deficit/Hyperactivity Disorder OR ADHD
- attention regulation OR attention control OR sustained attention
- serious games OR game-based intervention OR digital games
- cognitive training OR digital therapeutics
- These terms were combined to identify studies examining the relationship between serious games and attentional or executive functioning outcomes in children with ADHD.

### Study Selection

Studies were selected according to predefined eligibility criteria to ensure that the literature included in this review was relevant to the research objective. Articles were eligible for inclusion if they were published in peer-reviewed scientific journals and focused on children or adolescents diagnosed with Attention-Deficit/Hyperactivity Disorder (ADHD). In addition, studies were required to investigate serious games or digital game-based interventions designed for cognitive or behavioral training. Only studies reporting outcomes related to attention regulation, attentional control, or other closely related executive functioning processes were considered. To ensure the relevance and timeliness of the evidence, only articles published in English within the last ten years were included in the review. Studies were excluded if they focused exclusively on entertainment video games without therapeutic or cognitive training objectives. Articles involving adult

populations only were also excluded, as the present review specifically focuses on interventions for children and adolescents with ADHD. In addition, publications that did not address ADHD or attention-related cognitive outcomes were not considered. Non-peer-reviewed materials, including editorials, opinion papers, and publications lacking empirical or theoretical analysis, were also excluded from the review.

### Data Extraction and Synthesis

Relevant articles identified through the search process were screened based on their titles and abstracts to determine eligibility. Full-text articles that met the inclusion criteria were then reviewed in detail. Key information extracted from the selected studies included:

- study objectives
- participant characteristics
- type of serious game intervention
- targeted cognitive functions
- reported outcomes related to attention regulation

The findings from the selected studies were then synthesized narratively to identify recurring themes regarding the effectiveness of serious games in improving attentional processes among children with ADHD. Particular attention was given to intervention design features, mechanisms of cognitive engagement, and reported improvements in attentional performance.

### ETHICAL CONSIDERATION

As this research involved analysis of previously published studies, ethical approval was not required.

## RESULTS

### Overview of the Selected Literature

The included literature consistently examined the application of serious games and digital game-based interventions as cognitive training tools for children with Attention-Deficit/Hyperactivity Disorder (ADHD). Across studies meeting the predefined selection criteria, a central focus emerged on the enhancement of attention regulation, alongside broader domains of executive functioning and behavioral control. Most interventions employed structured digital platforms designed to deliver repetitive cognitive tasks within interactive gameplay environments, frequently incorporating adaptive difficulty, real-time feedback, and reward-based reinforcement systems [4,6]. Across the body of evidence, attention regulation was one of the most consistently targeted and evaluated outcomes. The findings indicate that repeated engagement with serious game interventions was associated with improvements in sustained attention, attentional control, and task engagement. Although variability was observed in intervention duration, game design, and outcome measures, the overall pattern of results supports the potential utility of serious games as cognitive training tools in ADHD populations [5].

### Serious Game Design Features for Attention Training

A prominent theme across the reviewed studies was the integration of specific game design features that support attentional training through structured and adaptive engagement. Adaptive gameplay mechanisms were widely implemented, enabling task difficulty to dynamically adjust according to the player's performance. This approach appears to maintain an optimal challenge level, thereby promoting sustained engagement while minimizing disengagement due to task difficulty mismatch [4]. In parallel, multisensory feedback systems including visual cues, auditory signals, and immediate performance feedback were consistently incorporated to guide attentional focus and reinforce task-related behavior. These mechanisms provide continuous external regulation of attention, which may be particularly beneficial for children with ADHD who experience intrinsic difficulties in self-directed attentional control. Reward-based reinforcement systems also emerged as a central design component. Points, levels, and achievement-based incentives were embedded within gameplay to enhance motivation and sustain participation. Given the documented alterations in reward sensitivity and dopaminergic functioning in ADHD, such reinforcement structures may play a critical role in facilitating engagement and persistence during cognitively demanding tasks [3].

### Effects of Serious Games on Attention Regulation

The reviewed evidence demonstrates a generally positive effect of serious games on attention regulation outcomes. Improvements were most consistently observed in sustained attention, attentional control, and task persistence following repeated exposure to game-based interventions. Several studies reported that children engaging in serious game training showed enhanced ability to maintain focus during prolonged or cognitively demanding activities [5,6]. In addition to cognitive outcomes, behavioral improvements were also reported. These included reductions in distractibility, increased task completion rates, and improved on-task behavior during structured activities. Such findings suggest that the effects of serious games may extend beyond laboratory-based cognitive measures to functional behavioral domains relevant to everyday settings, including classroom participation. However, the magnitude and consistency of these effects varied across studies, likely reflecting differences in intervention intensity, duration, and game design characteristics. Despite this variability, the convergence of findings supports the role of repeated and structured gameplay exposure in facilitating improvements in attention regulation among children with ADHD.

### Neurocognitive Mechanisms Supporting Attention Training

Several studies explored the neurocognitive mechanisms underlying the observed effects of serious game interventions. Evidence from neurocognitive and neuroimaging research suggests that game-based cognitive training may engage neural systems implicated in attention regulation, particularly within prefrontal and fronto-striatal

networks [2]. These regions are critically involved in executive functioning, including inhibitory control, sustained attention, and goal-directed behavior. Repeated engagement in gameplay tasks requiring sustained focus, rapid decision-making, and response inhibition may contribute to the strengthening of these neural circuits through experience-dependent neuroplasticity. Furthermore, the integration of reward-based systems within serious games is hypothesized to modulate dopaminergic pathways associated with motivation and reinforcement learning. This mechanism may enhance task engagement and persistence, thereby indirectly supporting improvements in attentional control [3]. Collectively, these findings suggest that serious games operate not only as behavioral training tools but also as interventions that may influence underlying neurocognitive processes associated with attention regulation.

### Summary of Key Findings

The synthesized evidence indicates that serious games represent a promising digital approach for enhancing attention regulation in children with ADHD. Across studies, these interventions consistently incorporated adaptive cognitive challenges, multisensory feedback, and reward-based reinforcement systems that facilitate sustained engagement in attentional training tasks. While effect sizes and outcomes varied, the overall pattern of findings supports the conclusion that repeated exposure to serious game-based interventions may contribute to improvements in sustained attention, attentional control, and related behavioral outcomes. These results position serious games as potentially valuable complementary tools within multimodal intervention frameworks aimed at improving executive functioning and attentional regulation in ADHD populations.

### DISCUSSION

The findings of this review suggest that serious games offer a promising and theoretically grounded approach to supporting attention regulation in children with ADHD. Across the literature, these interventions consistently combine structured cognitive tasks with adaptive and engaging gameplay elements, enabling repeated practice of attentional processes within motivating environments. This is particularly relevant for children with ADHD, who often struggle to sustain attention and maintain task persistence in conventional therapeutic and educational settings [1]. A key feature contributing to the effectiveness of serious games is the use of adaptive gameplay systems. By continuously adjusting task difficulty according to the child's performance, these systems help maintain an optimal level of challenge. Tasks that are too difficult may lead to frustration, while those that are too easy risk disengagement; adaptive calibration helps balance these extremes [4]. As a result, children are more likely to remain engaged while gradually developing attentional control through repeated exposure to appropriately challenging tasks.

Multisensory feedback also appears to play an important role in sustaining attention during gameplay. Visual cues, auditory signals, and immediate performance feedback provide continuous guidance, helping children stay oriented toward task goals. For individuals with ADHD who often experience difficulties in self-directed regulation, this external structure can support attentional focus and behavioural adjustment in real time. The consistent pairing of actions and feedback reinforces learning processes and may strengthen the association between effort and outcome. From a neurocognitive perspective, these behavioural improvements can be understood in relation to the neural systems underlying executive functioning. Attention regulation is supported by fronto-striatal and fronto-parietal networks, particularly involving the dorsolateral prefrontal cortex and anterior cingulate cortex, which are responsible for cognitive control and response monitoring [2]. Atypical activation within these regions is commonly observed in children with ADHD. Engaging in tasks that require sustained focus, rapid responses, and inhibition may promote experience-dependent neuroplasticity, gradually strengthening these neural circuits and improving attentional capacity.

Motivational processes further enhance the impact of serious games. Reward-based elements such as points, levels, and achievements provide immediate reinforcement, which is especially meaningful in ADHD, where sensitivity to delayed rewards is often reduced [3]. By delivering consistent and immediate feedback, serious games help sustain motivation and encourage persistence in cognitively demanding tasks. This interaction between cognitive challenge and reward responsiveness reflects the integration of attentional and motivational systems emphasized in contemporary models of ADHD. The potential benefits of serious games may also extend into broader functional domains. Improvements in attention regulation can support more effective participation in classroom activities, increase task completion, and reduce distractibility. Structured game environments may also create opportunities for social interaction, particularly when collaborative or competitive elements are incorporated. These experiences can contribute to greater engagement and confidence, addressing some of the social difficulties often associated with ADHD.

At the same time, several limitations within the current evidence base should be acknowledged. Many studies involve small samples, short intervention periods, and variations in design and outcome measures, making it difficult to draw definitive conclusions. Although improvements in attention are frequently reported, evidence regarding long-term effects and generalization to everyday functioning remains limited. These gaps highlight the need for more rigorous and standardized research approaches. Serious games should therefore be viewed as complementary tools rather than standalone treatments.

Pharmacological interventions, behavioural therapies, and educational support remain central to ADHD management. Within this broader framework, serious games may enhance engagement, provide structured cognitive training, and offer accessible opportunities for repeated practice. Their value lies in augmenting existing interventions rather than replacing them.

Future research would benefit from larger randomized controlled trials with longer follow-up periods to assess sustainability of effects. Greater consistency in intervention design and outcome measurement would also improve comparability across studies. Exploring how these tools can be integrated into clinical and educational settings, as well as examining their neurobiological impact, may further clarify their role in ADHD treatment. Overall, the evidence indicates that serious games represent a meaningful addition to current intervention strategies for ADHD. By combining adaptive challenges, structured feedback, and motivational reinforcement, they create environments that support attention regulation in a way that aligns with both cognitive and neurobiological models of the disorder. When incorporated into comprehensive care approaches, these tools have the potential to improve not only attentional functioning but also participation in daily activities.

## CONCLUSION

This narrative review examined the potential role of serious games as digital interventions for improving attention regulation in children with Attention-Deficit/Hyperactivity Disorder (ADHD). Attention regulation represents a core cognitive challenge in ADHD and significantly influences academic performance, behavioural control, and social functioning. The reviewed literature indicates that serious games may provide effective platforms for cognitive training by integrating adaptive task difficulty, multisensory feedback, and reward-based reinforcement systems that promote sustained engagement in attentional tasks. Findings from the analysed studies suggest that repeated engagement with serious game interventions may contribute to improvements in sustained attention, attentional control, and task persistence among children with ADHD. These improvements are thought to be supported by the activation of neural networks involved in attentional processing and motivational reinforcement. In addition, serious games may offer engaging and accessible environments that encourage participation in cognitive training activities. Despite these promising findings, serious games should be considered complementary tools within broader ADHD management strategies rather than replacements for established treatments. Future research involving larger samples, standardized intervention protocols, and long-term follow-up assessments is needed to further evaluate the effectiveness and clinical applicability of serious game interventions.

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