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The impact of technology use on cognitive development and lexical attrition in L1 and L2 among younger students with ADHD: Opportunities and challenges

Abdullah Al Fraidan, Thamer Alharthi[1]

Abstract:

BACKGROUND: The widespread integration of technology in education offers both exciting opportunities and significant challenges, particularly for learners with attention-deficit/hyperactivity disorder (ADHD). While digital tools can provide interactive and personalized learning experiences, ADHD students face cognitive difficulties that may impair their ability to retain vocabulary in both first (L1) and second (L2) languages.

OBJECTIVE: This study examines the complex relationship between ADHD, technology use, and lexical attrition, focusing on how working memory deficits, fragmented attention, and cognitive overload contribute to vocabulary loss. It introduces the Cognitive-Behavioral Technology Interaction (CBTI) Framework to explain these interactions and explore how technology can be optimized to mitigate its negative effects.

METHODS: A conceptual analysis was conducted, integrating cognitive theories such as Cognitive Load Theory (CLT), Monitor Theory, and the Working Memory Model (WMM). The study synthesizes existing research on ADHD and lexical attrition, particularly within digital learning environments, to develop structured recommendations for improving vocabulary retention.

RESULTS: Findings suggest that digital environments characterized by multitasking and rapid stimuli exacerbate vocabulary loss in ADHD learners. However, when used strategically, technological interventions such as spaced repetition systems (SRS) can enhance vocabulary retention by reintroducing words at optimal intervals. Structured, distraction-free learning environments were identified as essential for supporting ADHD students' cognitive needs.

CONCLUSION: The study underscores the need for collaboration between educators and healthcare providers to design effective, structured technological interventions for ADHD learners. By implementing targeted strategies, technology can shift from a challenge to a supportive tool for language retention and improved educational outcomes.

Keywords:

ADHD, lexical attrition, multitasking, spaced repetition systems, technology use, working memory

Department of English Language, King Faisal University, Saudi Arabia, [1]Department of Foreign Languages, King Abdulaziz University, Saudi Arabia

Address for correspondence:
Prof. Abdullah Al Fraidan, Department of English Language, King Faisal University, Al Ahsa, Saudi Arabia.
E-mail: afridan@kfu.edu.sa

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Introduction

The integration of technology into education has revolutionized the way students learn, offering unprecedented access to information and interactive tools. From digital classrooms to gamified learning platforms, these innovations promise to enhance educational engagement and outcomes. However, their long-term developmental implications, particularly for learners with neurodevelopmental conditions like attention-deficit/

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hyperactivity disorder (ADHD), remain underexplored. ADHD, characterized by persistent inattention, hyperactivity, and impulsivity, significantly impacts cognitive processes essential for learning, including working memory, attention regulation, and executive functioning.[1] These challenges are especially pronounced in language learning, where sustained focus and repeated exposure are critical for acquiring and retaining vocabulary in first (L1) and second (L2) languages.

Within this context, lexical attrition—the gradual loss of vocabulary—emerges as a critical developmental concern. Research indicates that ADHD learners are particularly vulnerable to lexical attrition due to their cognitive profiles, which hinder the consistent, deliberate language practice necessary for long-term retention.[2,3] The fast-paced, multitasking nature of digital environments further exacerbates these vulnerabilities, contributing to a fragmented learning experience and impeding cognitive engagement.[4] These dynamics are especially problematic in developmental stages where cognitive and linguistic skills are rapidly evolving, as disruptions during these critical periods can have cascading effects on academic and social outcomes.

While technology poses challenges, it also offers unique opportunities to address the cognitive limitations of ADHD learners. Tools such as SRS and interactive language learning apps have been shown to support vocabulary retention by reducing cognitive load and providing repeated, strategic exposure to language.[5] However, realizing these benefits requires a structured approach that accounts for the developmental needs of ADHD learners and mitigates the risks of cognitive overload.

This article introduces the cognitive-behavioral technology interaction (CBTI) framework, which integrates cognitive load theory (CLT), monitor theory, and the working memory model (WMM) to explain how ADHD learners interact with technology and how these interactions influence lexical attrition. By exploring the interplay between cognitive challenges, technological design, and developmental processes, the framework provides a theoretical foundation for understanding vocabulary loss in ADHD learners. The article also offers practical recommendations for leveraging technology to support language retention while minimizing its risks, emphasizing the importance of tailored interventions during critical developmental periods.

The novelty of this study lies in its interdisciplinary approach, integrating cognitive theories with technological frameworks to analyze lexical attrition among ADHD learners. While previous research has explored the cognitive challenges of ADHD students, limited studies have examined how digital learning environments impact their language retention in first (L1) and second (L2) languages. By introducing the CBTI framework, this research provides a new theoretical model that explains how multitasking, cognitive overload, and fragmented attention affect vocabulary loss in ADHD learners.

This study aims to investigate the relationship between ADHD, technology use, and lexical attrition in language learning. Specifically, it seeks to understand how working memory deficits and cognitive overload contribute to vocabulary loss in ADHD students using digital learning tools. Additionally, the study explores effective technological interventions, such as SRS, to mitigate the risk of lexical attrition and enhance long-term language retention.

The key innovation of this research is the development of the CBTI Framework, which integrates CLT, Monitor Theory, and the WMM to provide a structured explanation of ADHD learners' interaction with technology. Unlike previous studies that focus only on ADHD's impact on learning, this framework bridges cognitive science and educational technology, offering practical insights for educators, curriculum developers, and policymakers to design ADHD-friendly digital learning environments.

Unlike prior research that primarily focuses on ADHD and general academic performance, this study takes a linguistic and cognitive approach to examine how digital environments influence lexical attrition. Most existing studies have not fully explored the role of digital distractions, multitasking, and information overload in vocabulary loss among ADHD learners. By incorporating empirical evidence and theoretical models, this research extends the current understanding of technology's dual role—as both a barrier and a potential solution for enhancing language retention in ADHD students.

Materials and Methods

Study design and setting

This study employs a theoretical and conceptual approach to examine the complex interplay between ADHD, technology use, and lexical attrition. The research is designed to develop the CBTI framework, which integrates cognitive and linguistic theories to explain vocabulary retention challenges among ADHD learners in digital environments. The study is conducted as a conceptual synthesis rather than an empirical investigation, utilizing existing interdisciplinary literature to establish the theoretical framework.

Study participants and sampling

Since this is a conceptual and theoretical study, there are no direct study participants or sampling procedures involved. Instead, the research draws on prior studies from the fields of educational psychology, applied linguistics, and cognitive neuroscience, analyzing data from previous empirical research on ADHD learners and technology use.

Data collection tool and technique

The data collection for this study involves a systematic literature review and theoretical synthesis of existing research. Key studies were identified and analyzed based on the following recurring themes:

- Cognitive Load Theory[5]: Explaining the impact of cognitive overload on ADHD learners.
- Monitor Theory[6]: Highlighting the role of reflective monitoring in language retention.
- The WMM[7]: Addressing working memory limitations in ADHD learners.
- Empirical studies[4,8]: Demonstrating the effects of technology on ADHD learners' cognitive processes.

This analysis revealed the interdependence of cognitive mechanisms, digital learning environments, and lexical attrition, underscoring the need for a unified theoretical framework.

Ethical considerations

As this study is a conceptual framework development based on existing literature, there are no direct human participants, and thus no ethical approval or informed consent process was required. However, the study adheres to academic integrity and research ethics principles, ensuring that all sources are properly cited and that the synthesis of existing research is conducted objectively and transparently.

Statistical analysis method

Since this research does not involve primary data collection or statistical testing, no quantitative statistical analysis was conducted. Instead, qualitative thematic analysis was employed to identify patterns and relationships within the reviewed literature. The CBTI framework was constructed through:

- Identifying cognitive challenges specific to ADHD learners (e.g., fragmented attention, working memory deficits).
- Analyzing technological factors (e.g., multitasking, digital content design) that influence vocabulary retention.
- Proposing structured interventions (e.g., spaced repetition systems, distraction-free tools) to mitigate cognitive overload and enhance language retention.

This theoretical model provides a structured foundation for future empirical research to validate its applicability and effectiveness in educational settings.

This study does not present primary empirical data but rather synthesizes existing research to propose a conceptual model for understanding lexical attrition among ADHD learners in digital environments. Future research should empirically test the CBTI Framework in diverse educational contexts to evaluate its practical applications and effectiveness.

A framework to explain the relationships: The cognitive-behavioral technology interaction (CBTi) framework

The CBTI framework integrates several cognitive theories—CLT, monitor theory, and the WMM—to explain how technology affects vocabulary retention in ADHD students.

Cognitive load theory (Clt)

CLT[5] posits that working memory has a limited capacity for processing new information, and when overloaded, learning becomes ineffective. ADHD students are already prone to working memory deficits, attention control issues, and difficulties in executive functioning.[1] The fast-paced, multitasking nature of many technological platforms (e.g., social media, gaming) exacerbates cognitive overload,[9-11] hindering ADHD learners' ability to focus and retain new vocabulary in both L1 and L2.

Research by[3] identifies social media platforms as predictors of lexical attrition, noting that their reliance on short, informal communication reduces opportunities for practicing and retaining academic or complex vocabulary. For ADHD students, the allure of social media and technology as entertainment can reduce the time spent engaging in meaningful language activities, contributing to both L1 and L2 attrition. Reference[4] further emphasizes that students with ADHD struggle with the working memory demands of managing multiple stimuli, thereby limiting their ability to encode and retain vocabulary.

Monitor theory and language attrition

Krashen's monitor theory[6] plays a critical role in explaining how language learners use their internal cognitive resources to self-correct language errors during comprehension and production. According to the theory, learners must be focused and aware in order to activate their internal "monitor" system, which allows them to reflect on and adjust their language use, particularly in terms of grammar and vocabulary.[12] For learners to benefit from this monitoring process, they need sufficient attention and cognitive engagement to process language inputs effectively and apply learned language

rules during output (see more:[13-16]). For students with ADHD, however, engaging this internal monitor presents a significant challenge. ADHD is associated with impairments in attention, working memory, and executive functioning,[1] all of which are crucial for the kind of cognitive focus required to activate Krashen's monitor. These students often struggle to sustain attention long enough to make conscious corrections in their language use, meaning they are less likely to engage in reflective practice, a key component in reinforcing vocabulary retention. This issue is especially acute in second language (L2) learning, where students need to be attentive and deliberate to improve proficiency.[17]

A study by[2] emphasizes the importance of consistent and deliberate language practice for reinforcing vocabulary retention. Without frequent and mindful engagement with language—whether in L1 or L2—lexical items tend to fade from memory over time. This is especially problematic for ADHD learners, who already face cognitive challenges that hinder their ability to focus on the language learning process. The ability to recall vocabulary relies on both short-term practice and long-term reinforcement through repeated exposure and usage, and ADHD students may find it difficult to maintain the level of attention required for this.

Moreover, technology-driven environments—which are highly stimulating and often encourage multitasking—can further disrupt the monitoring process. While technology can offer ADHD students more interactive and engaging ways to learn language, these benefits are often undermined by the distractions inherent in multitasking. The constant influx of stimuli from notifications, pop-ups, and the rapid switching between applications diminishes the cognitive engagement necessary for deep language processing. In such environments, ADHD students are more likely to focus on superficial interactions with content rather than engaging with language at a level that would activate the monitor and support vocabulary retention.

Krashen's Affective Filter Hypothesis,[6] which is related to the monitor theory, also helps explain why ADHD students may struggle with vocabulary retention in these technology-rich contexts. According to this hypothesis, learners' emotional states, such as stress or frustration, can create a mental block—referred to as an "affective filter"—that prevents language input from being processed effectively. ADHD learners, who are prone to frustration due to their attention difficulties, may experience heightened anxiety in complex or fast-paced digital environments, further inhibiting their ability to focus on the language material at hand. Consequently, their internal monitor is less likely to be engaged, leading to increased rates of lexical attrition.

Technology's role in exacerbating this challenge is evident in environments where ADHD students are encouraged to multitask, such as while using social media, where brief and informal language interactions dominate. Reference[3] discusses how these platforms, while providing opportunities for language use, promote fragmented and shallow communication, which does not provide the level of cognitive engagement required for activating Krashen's monitor. This fragmented language exposure leads to reduced opportunities for practicing complex or academic vocabulary, contributing to attrition. For ADHD students, who are already struggling to focus, such environments pose additional cognitive challenges, further reducing their ability to engage in deep, reflective language practice.

In addition, ADHD learners often have reduced working memory capacity,[4] which exacerbates their difficulty in holding on to vocabulary long enough for it to be monitored and corrected.[17] notes that working memory is crucial for the rehearsal of new information, especially vocabulary, as it allows students to repeat and refine their usage. If ADHD learners are overwhelmed by technology's rapid pace and distractions, they are less likely to engage in the repeated use and monitoring of vocabulary, which in turn accelerates lexical attrition.

Practical examples of this challenge can be seen in online learning environments,[18] where ADHD students may switch between language-learning apps, games, and other content quickly, without spending enough time on any single task to engage their internal monitors fully. For instance, a student learning new vocabulary on a language app may be interrupted by notifications or the temptation to browse other content. This constant switching prevents the deep engagement required to not only acquire new words but also monitor and correct usage. Without sustained attention and cognitive engagement,[19] these vocabulary items are unlikely to be transferred into long-term memory, leading to higher rates of attrition.

In sum, Krashen's monitor theory provides a valuable lens through which to understand the challenges ADHD students face in language learning, particularly in the context of technology use. The fragmented and multitasking nature of digital environments interferes with the cognitive focus required to activate the monitor, thereby reducing opportunities for vocabulary reinforcement and leading to increased lexical attrition. Understanding these challenges allows educators and technology designers to create more structured, distraction-free learning environments that can help ADHD students overcome these barriers and engage more deeply with language.

The working memory model (WMM) and ADHD

The working memory model, introduced by[7], plays a crucial role in understanding how learners store, manipulate, and use information for complex cognitive tasks, including language learning and retention. Working memory, a system with limited capacity, allows individuals to temporarily hold and process information, which is essential for activities like problem-solving, reasoning, and language acquisition. For learners to acquire and retain vocabulary, their working memory needs to manage incoming linguistic information, rehearse it, and consolidate it into long-term memory.[17]

For students with ADHD, working memory deficits are a defining feature. ADHD learners often struggle with the executive functions necessary for sustaining attention, organizing tasks, and controlling impulses.[1] These cognitive impairments make it difficult for them to hold onto new information long enough to process it effectively. In the context of language learning, where new vocabulary and grammar rules must be actively rehearsed and integrated into existing knowledge, these working memory limitations present significant obstacles.

Research shows that working memory plays a pivotal role in vocabulary acquisition. When learning new words, students must engage in a process of repetition and rehearsal to transfer vocabulary from short-term memory into long-term storage.[17] The more a learner interacts with a word—whether through speaking, writing, or listening—the stronger the memory trace becomes, making it easier to recall in future situations. However, students with ADHD, who have reduced working memory capacity, may not engage in enough repetitions of a word for it to be fully encoded, leading to lexical attrition over time.

The role of technology in exacerbating working memory deficits

In modern educational environments, digital tools and technologies are increasingly used to facilitate language learning. These tools offer interactive and engaging ways to learn new vocabulary, including apps, games, and online exercises. However, for ADHD learners, the digital environment often comes with a host of distractions that can overload the limited capacity of working memory.

Multitasking is a common feature of digital tool use, whether it is switching between different apps or managing simultaneous inputs like videos, quizzes, and notifications. While neurotypical students may have the cognitive resources to manage such stimuli, ADHD students are much more vulnerable to cognitive overload. Research by[4] shows that ADHD students are already working with a lower working memory capacity, which means that the added pressure of multitasking in a digital context can overwhelm their ability to retain vocabulary effectively.

For instance, an ADHD student using a language-learning app might also be tempted to check notifications from social media, listen to music, or browse the internet. Each of these distractions competes for working memory resources, which are already in short supply. This fragmented attention prevents the learner from fully focusing on rehearsing new words, making it more likely that the vocabulary will not be consolidated into long-term memory and will instead be forgotten.

Furthermore, digital environments that demand quick responses—such as timed quizzes or fast-paced educational games—can further strain working memory in ADHD students. These tools require learners to process information rapidly and react quickly, which often leads to superficial learning rather than the deep processing needed to encode new words. As a result, ADHD learners may not spend enough time interacting with vocabulary items to commit them to memory, leading to poor retention in both first language (L1) and second language (L2) contexts.

Strategies to mitigate working memory overload in ADHD learners

Despite these challenges, there are structured approaches and technology-based interventions that can help ADHD students manage their working memory limitations while learning vocabulary. One such strategy is the use of SRS,[20] which are designed to optimize the retention of information by reintroducing it at increasing intervals based on the learner's performance.

SRS have been shown to be highly effective for reinforcing vocabulary, especially for students with working memory deficits.[8] These systems work by spacing out the review of vocabulary words at carefully calibrated intervals, allowing learners to revisit the words just as they are on the verge of forgetting them. This technique strengthens the memory trace of each word without overwhelming working memory, making it easier for ADHD students to retain vocabulary over time.

For ADHD learners, spaced repetition has several advantages:

1. Minimized Cognitive Load: Rather than cramming vocabulary in short bursts, spaced repetition spreads learning across time, reducing the pressure on working memory. By spacing out vocabulary practice, ADHD students can focus on fewer words at a time, making it more manageable for their cognitive capacities.

2. Consistent Re-engagement: Spaced repetition ensures that learners revisit vocabulary at critical moments, preventing the kind of long gaps that can lead to lexical attrition. This repeated exposure helps consolidate vocabulary into long-term memory, even for ADHD learners who might struggle with sustained focus.
3. Gamified Learning: Many spaced repetition tools incorporate game-like elements, such as progress tracking, rewards, and levels, which can be particularly motivating for ADHD students (see[21,22]). These features keep students engaged without overwhelming their cognitive resources, making language learning more enjoyable and effective.

In addition to spaced repetition, other digital tools designed for single-task focus can help ADHD learners maximize their working memory resources. For example, focus-enhancing apps that block distractions or provide structured, timed language exercises can help students maintain attention on vocabulary tasks. By minimizing the competing stimuli that typically lead to cognitive overload, these tools allow students to fully engage their working memory in the learning process, leading to better vocabulary retention.

Practical example: Using digital tools for ADHD learners

An example of an effective approach for ADHD learners is combining spaced repetition apps like Anki or Quizlet with distraction-free environments. In this setup, an ADHD learner might use a spaced repetition app for 10-15 min, focusing on a small set of vocabulary words. The app will present these words at intervals tailored to the learner's forgetting curve, ensuring that each word is revisited at just the right time to prevent forgetting. The use of such apps in a distraction-free mode ensures that the learner's working memory is focused solely on the vocabulary task at hand, without being overwhelmed by external inputs.

Furthermore, incorporating brief, focused practice sessions into a student's routine can also help manage working memory limitations. Research suggests that ADHD students benefit from shorter, more frequent study sessions rather than longer, continuous ones.[17] Structured tools that encourage bite-sized learning, like Pomodoro timers combined with vocabulary apps, can ensure that students are engaging in focused language practice without overloading their cognitive systems.

The WMM[7] provides an essential framework for understanding the cognitive challenges ADHD students face when learning vocabulary. Working memory deficits make it difficult for these students to store, rehearse, and consolidate new words into long-term memory. While technology offers exciting opportunities for interactive language learning, the multitasking nature of digital environments can easily overwhelm ADHD learners, leading to poor vocabulary retention and increased lexical attrition (see[23-29]).

However, structured interventions like SRS and focus-enhancing digital tools offer promising solutions. By reducing cognitive load and providing structured, repeated exposure to vocabulary, these tools help ADHD students manage their working memory limitations and enhance long-term retention in both L1 and L2 learning contexts. Educators and developers should continue to explore these strategies to better support ADHD learners in overcoming the challenges of working memory deficits in language acquisition.

Discussion

The findings of this study align with prior research on ADHD and lexical attrition, emphasizing the impact of cognitive overload and multitasking in digital environments. ADHD learners face significant challenges in maintaining vocabulary retention due to working memory deficits, fragmented attention, and executive functioning impairments. This study highlights how technology use can both exacerbate and mitigate these challenges, depending on how digital tools are structured.

Previous research, such as[4], has demonstrated that ADHD learners have reduced working memory capacity, which affects their ability to store and retrieve vocabulary efficiently. This study extends these findings by incorporating theoretical models that explain how digital multitasking environments further strain cognitive resources, leading to lexical attrition. Similar conclusions were reached by[17] who emphasized the role of working memory in language retention and its vulnerability in ADHD learners.

In contrast to studies that focus solely on the negative impact of technology on attention and cognition, this study identifies strategies that can leverage technology to support vocabulary retention (see[12-16,30]). The results support[8] findings that SRS enhance memory retention by strategically reintroducing vocabulary at optimal intervals. While previous research has demonstrated that SRS improves learning outcomes in general populations, this study suggests that it may be particularly effective for ADHD learners by reducing cognitive overload and reinforcing long-term memory retrieval.

Moreover, this study builds upon[6] monitor theory, which explains the role of conscious reflection in language retention. Prior research has found that ADHD

learners struggle to engage their internal monitor due to disruptions in sustained attention and cognitive control.[2] This study extends that understanding by showing that technological distractions further diminish the ability of ADHD learners to engage in reflective language practice, leading to increased lexical attrition.

A key difference between this study and previous work is the introduction of the CBTI framework, which integrates CLT, monitor theory, and the WMM to provide a structured explanation of how digital learning environments interact with ADHD cognitive processes. Unlike previous research that treats technology as a binary factor—either beneficial or detrimental—this study presents a nuanced perspective, arguing that structured technological interventions can counteract cognitive difficulties when designed appropriately.

Comparing these findings with those of[3], who examined social media's role in lexical attrition, it becomes clear that unstructured digital interactions lead to superficial language engagement and reduced retention. However, this study differentiates itself by demonstrating that structured learning technologies, such as spaced repetition and distraction-free learning environments, can actively support ADHD learners in overcoming memory and attention challenges.

The results also align with[7], who examined the effects of digital media on cognitive development and found that excessive screen time negatively impacts attention regulation. This study reinforces those findings while adding a language-learning dimension, showing that excessive exposure to unstructured digital content accelerates lexical attrition. However, it also suggests that purposeful digital interventions can create an adaptive learning environment tailored to ADHD students' cognitive profiles.

Overall, these findings emphasize the importance of structured digital interventions in mitigating lexical attrition for ADHD learners. While past research has largely focused on either ADHD's cognitive challenges or technology's impact on learning, this study bridges these perspectives to offer a comprehensive framework. By comparing previous studies and integrating their insights, this research provides a new theoretical and practical contribution to understanding how digital environments shape vocabulary retention in ADHD learners.

Practical implications for education and health

Educational implications

1. **Technology design and implementation**: Educators should integrate technology in ways that minimize cognitive load and support ADHD learners. Tools like SRS, which reintroduce vocabulary at spaced intervals, help ADHD students reinforce vocabulary in both L1 and L2, thereby reducing the risk of lexical attrition.[8] Additionally, apps that limit multitasking and focus on one task at a time can help mitigate the cognitive overload that often impedes ADHD learners.
2. **Structured language practice**: Schools should emphasize structured, deliberate practice in language learning. Krashen's monitor theory[6] highlights the importance of self-correction and focused attention for language acquisition. Teachers should design classroom activities that require sustained attention to vocabulary tasks, such as writing exercises or monitored group discussions. This can help ADHD learners maintain their focus on vocabulary and prevent attrition.
3. **Professional development for teachers**: Teachers need specialized training to understand the cognitive challenges ADHD students face in technology-rich environments. Schools should offer professional development programs[31] that equip educators with strategies for managing cognitive load, minimizing distractions, and fostering reflective language practice in ADHD students.

Health implications

1. **Cognitive behavioral interventions**: Healthcare providers working with ADHD students should emphasize cognitive behavioral therapy (CBT) to teach students strategies for improving attention and reducing cognitive overload.[1] By developing attention-management techniques, ADHD learners can better focus on language retention tasks, reducing the likelihood of lexical attrition.
2. **Guidelines for technology use**: Pediatricians and psychologists should work with schools and parents to create technology use guidelines that limit screen time and ensure structured learning. Reference[28] recommends creating environments where ADHD students use technology for educational purposes rather than passive entertainment, which can exacerbate attention deficits and lexical attrition.
3. **Language therapy**: ADHD students who experience significant lexical attrition may benefit from language therapy, which focuses on reinforcing lost vocabulary and improving working memory capacity. Speech-language pathologists can design interventions that incorporate spaced repetition and goal-oriented vocabulary practice, using technology as an aid for language retention.

Limitation and recommendation

Despite the contributions of this study, several limitations should be acknowledged. First, this research is conceptual and theoretical in nature, relying on existing literature

rather than primary empirical data. While the CBTI framework provides a structured explanation of how digital environments influence ADHD learners' lexical retention, its effectiveness requires empirical validation through experimental or longitudinal studies. Future research should test this framework in real educational settings to determine its practical applications.

Another limitation is that the study does not account for individual differences among ADHD learners. ADHD manifests in various subtypes, including inattentive, hyperactive-impulsive, and combined types, each of which may respond differently to digital interventions. Further research should examine how different ADHD profiles interact with digital tools and whether specific technological adaptations are required for different learner subgroups.

Additionally, while this study highlights the potential benefits of structured digital interventions, such as SRS and distraction-free learning environments, it does not explore the long-term effects of technology use on ADHD learners. Longitudinal studies could provide deeper insights into how sustained exposure to digital learning environments influences language retention, cognitive development, and executive functioning over time.

A further limitation is that external environmental factors, such as social, emotional, and classroom dynamics, were not fully addressed. ADHD learners may experience additional challenges beyond cognitive load and technological distractions, such as peer interactions, anxiety, and motivation. Future research should adopt a multidimensional approach by considering how classroom structure, teacher strategies, and parental involvement influence the relationship between technology use and lexical retention.

Based on these limitations, several recommendations emerge for researchers, educators, and policymakers. First, empirical studies should be conducted to validate the CBTI Framework, incorporating quantitative and qualitative methodologies to assess the effectiveness of various digital interventions. Second, educational institutions should integrate structured technological tools, such as SRS and AI-based adaptive learning platforms, to support ADHD learners' vocabulary retention. These tools should be designed to minimize distractions while reinforcing spaced and repeated language exposure.

Furthermore, teacher training programs should incorporate strategies for managing ADHD learners in digital environments. Educators should be equipped with knowledge on how to design structured, low-cognitive-load digital lessons that prevent ADHD learners from being overwhelmed. Policymakers should also establish guidelines for ADHD-friendly digital education, ensuring that technological tools align with cognitive science principles to optimize language retention and learning outcomes.

Finally, future studies should explore personalized interventions tailored to different ADHD subtypes, using neuroscientific methods such as ***functional Magnetic Resonance Imaging*** Functional Magnetic Resonance Imaging (fMRI) and eye-tracking technology to examine how ADHD learners process digital language input. By refining our understanding of how ADHD learners interact with technology, educational stakeholders can design evidence-based interventions that support their academic success.

Conclusion

The CBTI framework provides a structured understanding of how ADHD-related cognitive challenges interact with digital environments in the context of lexical attrition. It emphasizes the importance of early interventions to address working memory limitations, fragmented attention, and cognitive overload, which impact language retention.

When properly designed, technology can serve as a supportive tool for ADHD learners. Structured educational interventions, such as spaced repetition systems (SRS) and single-task learning environments, help reduce cognitive load, enhance vocabulary retention, and improve sustained focus. Adaptive learning apps can further motivate students while minimizing distractions that contribute to lexical attrition.

However, the effectiveness of technology depends on its implementation. Multitasking and fragmented content can worsen cognitive difficulties, increasing the risk of vocabulary loss. Thus, it is crucial to integrate developmentally appropriate strategies that prioritize focused attention and deliberate practice.

Future research should empirically validate the CBTI framework by examining how specific technological interventions impact ADHD learners across different developmental stages. Collaboration among educators, psychologists, and technology developers is essential to designing effective digital learning tools that enhance language retention and cognitive development.

In conclusion, the CBTI framework highlights both the risks and benefits of technology for ADHD learners. Thoughtfully designed interventions, such as structured learning tools and distraction-free environments, can mitigate cognitive overload, prevent lexical attrition,

and enhance long-term educational outcomes. By aligning technological innovations with developmental psychology principles, educators and policymakers can empower ADHD learners to achieve their full academic potential.

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Authorship and approval statement

The manuscript has been read and approved by all authors, who confirm that the requirements for authorship have been met and that the manuscript represents honest work.

Additional information

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Conflicts of interest

There are no conflicts of interest.

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