Interdisciplinary Journal of Global and Multidisciplinary
IJGAM
ISSN xxxx-xxxx
+62852-3430-9925 https://jurnal-ijgam.or.id/ admin@jurnal-ijgam.or.id
Diterbitkan Oleh
PT. RADJA POS MEDIA
Vol. 2, No. 1, January 2026 | Page. 510 - 527

A LITERATURE REVIEW OF HOW SEARCH-ENGINE DEPENDENCY INFLUENCES MEMORY ENCODING AND COGNITIVE PROCESSES IN YOUNG ADULTS (18-25)

Ahmad Daffa Jamaludin
Al Azhar Islamic High School 17 Karawang, Indonesia
Email: daffajlbusiness@gmail.com

Keywords:

Digital Cognition,
Cognitive Offloading,
Search-Engine Dependency,
Memory Encoding,
Extended Mind,
Artificial Intelligence.

Abstract

Digital technologies have become deeply embedded in everyday cognitive activity, particularly through the widespread use of search engines and artificial intelligence for information access and problem solving. This literature review examines how digital reliance reshapes memory, learning, and broader cognitive processes. The review focuses on studies published between 2011 and 2025 involving young adults aged 18–25, a population characterized by high technology use and ongoing cognitive development. The scope includes research on search-engine dependency, cognitive offloading, and Internet reliance, with attention to their theoretical links to cognitive and neurocognitive mechanisms. The reviewed findings show that digital tools provide adaptive benefits by reducing cognitive load, increasing efficiency, and supporting higher-level reasoning when used strategically. At the same time, frequent and unreflective reliance on external information sources is associated with reduced depth of memory encoding, weaker long-term retention, and increased dependence on external systems. Evidence across studies highlights cognitive offloading as a key mechanism that explains both improved task performance and potential learning costs. The discussion integrates these findings within frameworks of outsourced cognition and the extended mind, emphasizing that cognition increasingly operates across internal and external systems. The review concludes that digital dependency produces context-dependent cognitive outcomes rather than uniform effects. Its contribution lies in clarifying how strategic versus habitual technology use shapes cognition, with important implications for cognitive psychology and education in the digital

INTRODUCTION

Digital technologies have reshaped how information is accessed, processed, and used in daily life. Search engines and AI-based systems allow instant retrieval of facts, explanations, and solutions with minimal effort, making external information availability a routine part of cognitive activity (Gerlich, 2025). This constant accessibility has become embedded in everyday thinking, influencing how people plan tasks, solve problems, and make decisions. Instead of relying solely on internal memory, individuals increasingly expect information to remain externally available. As a result, cognitive effort is often redirected from memorization toward locating and managing information sources. These changes affect not only what people know but also how they engage with knowledge in everyday contexts (Akhter, 2025).

The integration of digital access into cognition also alters learning habits and decision-making strategies. Many daily choices are supported by quick online searches or AI-generated suggestions, reducing the need for prolonged cognitive engagement (Gerlich, 2025). This pattern reinforces expectations of speed, convenience, and accuracy provided by digital tools. Over time, repeated reliance on external information sources shapes how attention and effort are allocated. Cognitive processes adapt to environments where answers are readily accessible, especially in educational and problem-solving contexts. These adaptations indicate that digital tools now play an active role in structuring cognitive behavior rather than merely supporting it (Akhter, 2025).

Several key concepts help explain how digital technologies interact with human cognition. Outsourced cognition refers to the delegation of cognitive tasks, such as remembering or evaluating information, to external tools and systems (Jose et al., 2025). Search-engine dependency describes a habitual reliance on digital platforms to access information rather than encoding it internally. Cognitive offloading captures the broader process of using external resources to reduce internal cognitive demand. Memory encoding refers to the transformation of information into durable mental representations. Together, these concepts describe how cognitive effort is redistributed between internal and external systems.

From a theoretical perspective, these processes align with extended cognition frameworks that view tools as integral components of cognitive systems (Jose et al., 2025). When individuals expect information to be continuously accessible, encoding strategies tend to shift toward surface-level processing. This shift has implications for long-term retention and conceptual understanding. Metacognitive control plays a central role in determining when individuals rely on internal memory versus external aids. These frameworks provide a foundation for examining how digital reliance shapes learning and cognition across contexts.

Empirical studies consistently demonstrate behavioral effects associated with digital reliance. The Google effect shows that individuals are less likely to remember information when they believe it can be easily accessed online. Research further indicates that people tend to remember the location of information rather than its content, reflecting changes in memory strategies (Akhter, 2025). Digital amnesia describes everyday forgetting linked to frequent use of digital devices as external memory stores. Studies on cognitive offloading show improved immediate task performance alongside reduced recall of offloaded information. These findings point to systematic changes in how memory resources are used.

Recent research extends these patterns to AI-based tools. AI-assisted search and content generation reduce the need for active information processing and increase reliance on externally generated outputs (Gerlich, 2025). Users often engage with AI-generated content without deep evaluation, influencing learning strategies and confidence judgments. Behavioral evidence suggests shifts in problem-solving approaches and reduced engagement with internal memory processes. These findings indicate that digital tools reshape both cognitive outcomes and the strategies used to achieve them.

Young adults represent a critical population for examining digital cognition. This age range corresponds to a phase of advanced but still-developing executive functions, including self-regulation and metacognitive monitoring. At the same time, young adults are among the most intensive users of search engines, smartphones, and AI-based systems (Rodrigues et al., 2025). Their academic and everyday activities are deeply integrated with digital technologies. Learning habits established during this period may influence long-term memory strategies and cognitive autonomy. These characteristics make young adults particularly relevant for studying digital reliance.

The interaction between ongoing cognitive maturation and high levels of digital exposure increases vulnerability to shifts in memory encoding strategies. Heavy dependence on external tools may influence how durable learning and self-directed cognition develop (Jose et al., 2025). Educational environments amplify these effects, as digital tools are central to studying, information retrieval, and assessment. Understanding cognitive offloading in this population is essential for evaluating its long-term implications. Young adults therefore provide a crucial lens for examining how digital tools shape cognition during a formative stage.

Despite extensive research on digital cognition, several limitations remain. Many studies emphasize behavioral outcomes without sufficiently integrating neurocognitive mechanisms underlying memory and attention changes. Research often treats cognitive offloading, extended mind theories, and digital addiction as separate domains, limiting conceptual synthesis (Rodrigues et al., 2025). In addition, young adults are frequently included in mixed-age samples without targeted analysis. This obscures age-specific patterns related to development and digital exposure. AI-based tools are also sometimes examined independently from search-engine use despite shared cognitive mechanisms.

There is limited integration between behavioral findings and broader psychological or neurocognitive frameworks. Long-term consequences of sustained reliance on AI and digital systems remain underexplored (Chirayath et al., 2025). Few studies directly address the balance between adaptive efficiency and potential cognitive costs within a unified model. Addressing these gaps requires integrative approaches that connect theory, behavior, and population-specific factors. Such synthesis is necessary to clarify how digital technologies reshape cognition in contemporary contexts.

LITERATURE REVIEW

Search-Engine Dependency and the Transformation of Memory Encoding

Search-engine dependency has fundamentally altered how individuals encode and store information in memory. Traditional memory encoding relies on sustained attention, elaborative rehearsal, and meaningful integration of new information with prior knowledge. However, when individuals expect information to remain continuously accessible through search engines, motivation to encode information deeply decreases.

This phenomenon aligns with the “Google effect,” where individuals show reduced recall for information they believe can be easily retrieved online. Instead of encoding content, users prioritize remembering where and how to access information, indicating a strategic shift in memory processes.

Studies suggest that this reliance encourages surface-level processing rather than semantic encoding, which is essential for long-term retention. When cognitive effort is redirected toward information retrieval strategies, encoding becomes more transient and context-dependent. Over time, this may weaken the formation of durable memory traces. Akhter (2025) argues that repeated exposure to externally stored knowledge reshapes expectations about memory responsibility, transferring it from the individual to digital systems.

From a cognitive perspective, this shift reflects an adaptive response to information-rich environments. However, it also introduces potential trade-offs. While efficiency in task completion may increase, depth of understanding and conceptual mastery may decline. This is particularly relevant in learning contexts where comprehension and transfer of knowledge are critical. Thus, search-engine dependency does not eliminate memory encoding but alters its nature, emphasizing accessibility over retention.

Cognitive Offloading and Outsourced Cognition in Digital Environments

Cognitive offloading refers to the use of external tools to reduce internal cognitive demands, such as memory load or problem-solving effort. Search engines represent a powerful form of cognitive offloading, enabling users to delegate remembering, calculating, and evaluating information to digital systems. Jose et al. (2025) describe this process as outsourced cognition, where tools become functionally integrated into cognitive routines.

Research shows that cognitive offloading can improve immediate performance and reduce mental fatigue. For example, individuals using external aids often complete tasks more efficiently and with fewer errors. However, this short-term benefit is often accompanied by reduced internalization of information. When cognitive tasks are consistently offloaded, individuals may engage less in active processing, leading to weaker memory encoding and reduced cognitive engagement.

Importantly, cognitive offloading is not inherently maladaptive. Within extended cognition frameworks, tools are viewed as legitimate components of cognitive systems. The key issue lies in over-reliance and reduced metacognitive regulation. When individuals default to external tools without evaluating task demands, they may underutilize internal cognitive resources. This can affect learning quality, especially in contexts requiring critical thinking or synthesis.

In digital environments where search engines and AI tools are omnipresent, cognitive offloading becomes habitual. Understanding how this habit shapes cognitive strategies is essential for evaluating its long-term impact on memory, reasoning, and autonomy.

Search-Engine Dependency and Changes in Attention and Cognitive Processing

Beyond memory, search-engine dependency influences broader cognitive processes, particularly attention allocation and depth of processing. Constant access to information encourages rapid scanning, multitasking, and fragmented attention. Rather than sustained focus, users engage in goal-directed searches aimed at extracting specific answers quickly. Gerlich (2025) notes that this pattern reinforces expectations of immediacy, shaping how individuals approach cognitive tasks.

Research indicates that frequent reliance on search engines reduces tolerance for cognitive effort. When answers are instantly available, individuals are less likely to engage in prolonged reasoning or reflective thinking. This can lead to shallow information processing, where content is consumed without integration or critical evaluation. Over time, such habits may influence cognitive styles, favoring speed and convenience over depth.

Attention is increasingly directed toward navigation and evaluation of sources rather than comprehension of content. While this may enhance information literacy skills, it can also reduce engagement with complex material. Cognitive load is redistributed rather than eliminated, shifting from internal processing to external coordination.

These changes highlight the adaptive but transformative nature of digital cognition. Cognitive processes adjust to environments where information abundance alters the cost-benefit balance of effortful thinking. Understanding these attentional shifts is crucial for assessing how search-engine dependency reshapes cognitive functioning in everyday and academic contexts.

AI-Assisted Search, Metacognition, and Learning Strategies

The integration of AI-based systems into search and information retrieval introduces new cognitive dynamics. Unlike traditional search engines, AI tools provide synthesized answers, explanations, and recommendations, further reducing the need for active information processing. Gerlich (2025) suggests that AI-assisted search intensifies cognitive offloading by minimizing user engagement with source material.

Metacognitive processes play a central role in mediating these effects. Users must decide when to trust AI outputs and when to engage in independent reasoning. However, studies show that individuals often overestimate the accuracy and completeness of AI-generated information, leading to reduced monitoring and evaluation. This can weaken learning outcomes and foster passive consumption of knowledge.

AI tools also influence confidence judgments. Users may feel knowledgeable after interacting with AI systems despite limited internal understanding. This illusion of competence can undermine motivation for deeper learning and memory encoding. Over time, reliance on AI may reshape learning strategies, prioritizing outcome efficiency over cognitive mastery.

While AI-assisted search offers substantial benefits, including accessibility and personalization, its cognitive implications require careful consideration. Understanding how AI alters metacognitive control is essential for balancing efficiency with meaningful learning and cognitive development.

Young Adults (18–25) as a Critical Population in Digital Cognition Research

Young adults represent a uniquely important population for studying search-engine dependency and cognitive offloading. This age range corresponds to a period of advanced yet still-maturing executive functions, including planning, self-regulation, and metacognitive monitoring. At the same time, young adults are among the most intensive users of digital technologies, integrating search engines and AI tools into nearly all aspects of daily life (Rodrigues et al., 2025).

Educational demands during this period rely heavily on digital information retrieval. Study habits, problem-solving strategies, and academic performance are increasingly shaped by external tools. As Jose et al. (2025) note, learning strategies developed during young adulthood may persist into later life, influencing long-term cognitive autonomy.

High levels of digital reliance may interact with ongoing cognitive development, affecting how memory encoding strategies are consolidated. While efficiency and adaptability may improve, there is concern that over-reliance on external systems could limit deep learning and self-directed cognition. Educational environments amplify these effects by normalizing constant access to information.

METHODS

Study Design

This study employed a systematic literature review design conducted in accordance with PRISMA guidelines. The review focused on empirical studies examining search-engine dependency, Internet reliance, and cognitive offloading, and their effects on memory encoding and cognitive processes. Only studies involving human participants were considered to ensure direct relevance to psychological and cognitive outcomes. The review targeted young adults aged 18–25 or populations in which this age group constituted a substantial proportion, such as university students. Conceptual papers, commentaries, and non-empirical articles were excluded. The final synthesis emphasized studies that provided behavioral, cognitive, or neurocognitive evidence related to digital information reliance.

Scope of the Review

The scope of this review was restricted to studies published between 2021 and 2025 to capture recent developments in digital cognition and AI-assisted information use. The population of interest was young adults (18–25 years), reflecting a developmental stage characterized by high digital engagement and ongoing refinement of cognitive strategies. The review focused on three main domains: (1) use of search engines, AI tools, or Internet-based information retrieval; (2) cognitive offloading behaviors and reliance on external memory systems; and (3) outcomes related to memory encoding, retention, learning, attention, and higher-order cognitive processes. Studies were required to establish a clear link between digital dependency and cognitive mechanisms.

Search Strategy

Literature searches were conducted across major scientific databases, including PubMed, ScienceDirect, Taylor & Francis, MDPI, Frontiers, Emerald, and PMC. The search strategy combined keywords related to digital information use and cognition, such as search engine use, Google effect, AI-assisted search, cognitive offloading, outsourced cognition, digital memory, learning, attention, and memory encoding. Boolean operators were adapted for each database to optimize retrieval. Reference lists of relevant articles were also manually screened to identify additional eligible studies. Only articles published in peer-reviewed journals and available in full-text PDF format were considered.

Screening Process (PRISMA)

1. Study selection followed the PRISMA framework through four stages.
2. Identification: All records retrieved from database searches and manual reference checks were compiled, and duplicate entries were removed.
3. Screening: Titles and abstracts were reviewed to assess relevance to search-engine

dependency, cognitive offloading, and cognitive outcomes.

4. Eligibility: Full-text articles were evaluated based on population age, study design, type of digital dependency examined, and relevance to memory or cognitive processes.

   Included: Studies meeting all criteria were included in the final synthesis.

PRISMA Flow Diagram

The PRISMA screening process resulted in a final selection of 20 peer-reviewed journal articles published between 2021 and 2025. These studies formed the basis of the qualitative. synthesis and results tables. A PRISMA flow diagram was constructed to illustrate the identification, screening, eligibility, and inclusion stages of the review process.

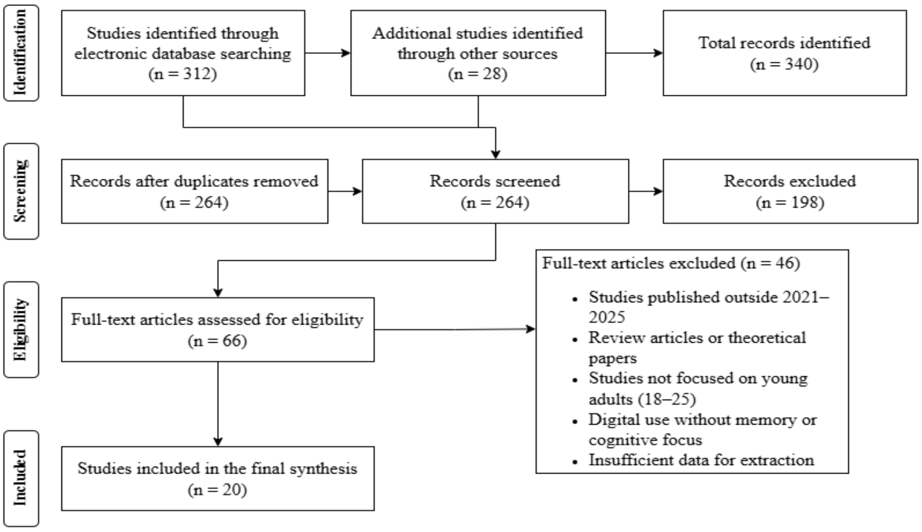

Figure 1. PRISMA Flow Diagram of study selection process.

Data Extraction and Synthesis

Data were extracted using structured tables capturing author information, publication year, sample characteristics, type of digital dependency, research methods, cognitive outcomes, theoretical framework, and key findings. The synthesis was conducted narratively to identify consistent patterns across studies rather than to calculate pooled effect sizes. Findings were organized according to major themes, including outsourced cognition, cognitive offloading, memory encoding, adaptive versus maladaptive effects, and neurocognitive implications. This thematic synthesis allowed integration across behavioral and theoretical perspectives.

Study Limitations

The reviewed studies varied in methodological approaches, definitions of digital dependency, and cognitive outcome measures. Many studies employed cross-sectional or short-term experimental designs, limiting causal interpretation. Differences in task paradigms, measurement tools, and participant characteristics contributed to heterogeneity across findings. Additionally, not all studies exclusively sampled young adults, requiring careful interpretation when generalizing results to the 18–25 age group. These limitations highlight the need for more standardized, longitudinal, and neurocognitively integrated research in future studies.

RESULTS AND DISCUSSION

Results

This section presents the main empirical patterns identified in the reviewed studies, with a focus on how digital dependency influences memory, learning, and cognitive processes. The results are synthesized to highlight consistent findings across different research designs, populations, and technological contexts, rather than to compare individual effect sizes. Attention is given to the forms of digital reliance examined, including search-engine use, Internet-based information seeking, and cognitive offloading strategies. The summary emphasizes observed cognitive outcomes, underlying mechanisms, and theoretical interpretations reported in the literature. To provide a structured overview, key characteristics and findings of representative studies are presented in the following table.

Author & Year	Population	Digital Dependency	Method	Cognitive Focus	Framework	Implications
Grinschgl et al., 2021	University students (young adults)	Cognitive offloading using digital tools	Laboratory experiments (Pattern Copy Task, delayed memory tests)	Working memory, long-term memory encoding	Cognitive offloading, extended mind, desirable difficulties	Offloading improves task speed but weakens later memory unless learning goals are explicit
Diotaiuti et al., 2021	Young adults (18–30), university students	Internet addiction	Cross-sectional survey with hierarchical regression	Impulsivity, emotional regulation, relational functioning	Behavioral addiction, self-regulation, relational psychology	Internet addiction in young adults is strongly predicted by impulsivity and relational codependency, indicating risks for emotional control, attention, and daily functioning
Grinschgl et al., 2023	Adults (18–42 years; majority young adults)	Cognitive offloading via external visual access	Dual-task experiment (pattern copy task + auditory N-back)	Working memory, multitasking performance	Cognitive offloading, flexible resource model	Greater offloading reduced working memory load and improved concurrent task accuracy by freeing internal cognitive resources

Murphy & Castel (2023)	Younger adults (18–31) and older adults (60–96)	External memory aids for selective offloading	Two lab experiments; word lists with objective values (Exp.1) and subjective importance (Exp.2); controlled offloading and recall tests	Memory offloading, value-based selectivity, aging	Metacognitive control; responsible remembering	Offloading follows value differently by age; younger adults prioritize objective value, older adults prioritize subjective importance; offloading important info can be risky if aids fail; design of memory aids should consider age and value type
Shanmugasundaram & Tamilarasu, 2023	Children, adolescents, adults, older adults	Digital technology, social media, AI use	Mini review of empirical and neuroscientific studies	Attention, memory, decision making, learning, addiction	Cognitive load, neuroplasticity, cognitive offloading	Digital tools reshape cognitive functions across domains; balanced and mindful use is needed to support cognitive health and reduce long-term risks
Richmond et al., 2023	Young adults (17–30 years, university students)	Cognitive offloading using external reminders	Three controlled online experiments (internal memory, partial offloading, full offloading)	Memory accuracy, retrieval of offloaded and non-offloaded information	Cognitive offloading, value-based remembering, metacognition	Offloading improves memory performance; full offloading yields the highest benefit, while partial offloading still enhances recall and can cue related non-offloaded information
Gong & Yang, 2024	Adolescents to older adults (ages 12–89; mixed	Intensive Internet search behavior (Google use; mobile and	Meta-analysis of 35 comparisons from 22 peer-reviewed	Memory retention, cognitive load, transactive memory	Google effect, cognitive offloading, media effects, transactive	Frequent Internet searching reduces content memory while strengthening reliance on

	global samples)	desktop)	studies	use	memory	external sources; effects are stronger on mobile devices and vary by region, knowledge base, and prior Internet experience
Frröscher et al., 2022	Adults (18–64 years; university students and online participants)	Use of external digital reminders instead of internal prospective memory	Two controlled experiments using an optimal reminders task with gain vs. loss framing	Prospective memory accuracy, metacognitive confidence, decision-making under uncertainty	Cognitive offloading, metacognition, framing effects	Framing reminders as losses reduces excessive reliance on external aids and promotes more optimal balance between internal memory use and digital support
Meyerhoff et al., 2021	University students (young adults)	Cognitive offloading using external reminders and visual references	Experimental tasks across two sessions	Short-term memory, prospective memory, offloading behavior	Extended mind and cognitive offloading	Offloading varies by task type and individual memory capacity, not as a single stable trait

Discussion

Outsourced Cognition and the Extended Mind

Digital technologies increasingly operate as external components of human cognition rather than as neutral tools. Search engines, cloud storage, note-taking applications, and AI systems now handle tasks that were once managed internally, such as recalling facts, organizing knowledge, and guiding problem-solving. In daily contexts, individuals often rely on devices to remember schedules, retrieve information, or make decisions, which effectively shifts part of cognitive processing outside the biological brain (Shin et al., 2025). This shift reflects a functional extension of the mind, where cognition is distributed across internal mental processes and external technological systems. The boundary between what is remembered internally and what is stored externally becomes fluid, shaped by convenience and perceived reliability. As a result, memory is no longer only a personal cognitive resource but also a networked process involving digital infrastructure.

From an extended mind perspective, digital tools can be understood as integrated elements of thinking rather than optional supports. When individuals repeatedly use search engines to answer questions, the act of searching itself becomes part of the cognitive routine. The mind adapts to this environment by prioritizing access strategies over content retention, a pattern frequently observed in AI-supported academic reading and annotation practices (Shin et al., 2025). Instead of encoding detailed information, individuals often encode where and how information can be retrieved. This reorganization does not imply the absence of cognition, but rather a redistribution of cognitive effort. Mental resources are redirected toward navigation, evaluation, and selection of information sources.

The outsourcing of cognition also reshapes attentional processes. When people expect that information can always be recovered later, sustained attention to details becomes less necessary. This expectation reduces the motivation to deeply process information during initial exposure, especially in environments dominated by digital media (Say et al., 2025). Digital environments reinforce this tendency by offering constant availability and low retrieval costs. As a consequence, attention is frequently fragmented, alternating between internal reasoning and external consultation. This mode of interaction encourages surface-level engagement with content rather than deep conceptual integration.

Extended cognition further influences metacognitive judgments about knowledge and competence. Individuals may feel more knowledgeable because they can access information quickly, even when internal understanding is limited. This perceived competence is grounded in access rather than mastery, which aligns with observations of confidence inflation in technology-rich environments (Kabashkin, 2025). Over time, reliance on external systems may blur the distinction between what is personally known and what is merely accessible. This blurring can affect confidence, decision-making, and self-assessment, particularly in academic and professional contexts. The cognitive system becomes optimized for environments where information is abundant and immediately available.

At the same time, outsourced cognition is not inherently detrimental. By reducing the need to store large volumes of information internally, digital tools can free cognitive capacity for higher-level tasks. Complex problem-solving, creative synthesis, and strategic planning may benefit from external memory support when tools are used as scaffolds rather than substitutes (Lee & Lee, 2025). The challenge lies in how these tools are integrated into cognitive routines. When external systems replace core cognitive engagement, learning may become shallow. When they support rather than substitute internal processing, they can enhance performance.

The extended mind framework highlights a shift in what it means to learn. Learning is no longer only about internalizing content, but also about developing effective strategies for interacting with information systems. Students may become skilled at searching, filtering, and combining information from multiple sources, particularly in AI-supported learning environments (Lee & Lee, 2025). However, if these skills are not accompanied by deep processing and reflection, conceptual understanding may remain fragile. The extended mind thus raises questions about the goals of education and the types of cognitive skills that should be cultivated.

Cognitive Offloading and Memory Encoding

Cognitive offloading refers to the deliberate or habitual transfer of cognitive tasks to external aids. In the context of digital search and AI use, offloading commonly occurs during information acquisition and memory formation. When individuals rely on devices to store or retrieve information, the cognitive demand placed on internal memory systems decreases, a process increasingly discussed in relation to AI–human interaction (Kabashkin, 2025). This reduction affects how information is encoded at the moment of learning. Encoding processes depend heavily on attention, elaboration, and meaningful engagement. When offloading is anticipated, these processes are often weakened, resulting in less robust memory traces.

Memory encoding is particularly sensitive to expectations about future access. If individuals believe that information will be easily retrievable later, they are less likely to invest effort in encoding details. This expectation changes learning strategies in subtle but consistent ways, similar to patterns observed when individuals anticipate reminders or external memory support (Peper & Ball, 2025). Rather than rehearsing information or linking it to existing knowledge, individuals may focus on completing tasks quickly. The cognitive system adapts by minimizing internal storage and maximizing external reliance.

Digital search environments further amplify this effect by emphasizing speed and efficiency. Search engines provide immediate answers, often without requiring users to process underlying explanations. This encourages shallow processing, where information is briefly encountered but not deeply integrated, a pattern also observed in digital media–based learning experiences (Say et al., 2025). Memory encoding under these conditions tends to be context-poor and fragmented. Users may remember the act of searching or the source of information, but not the content itself. As a result, retention over time is reduced.

Cognitive offloading also influences the structure of memory representations. When internal encoding is limited, memory traces may lack semantic richness and associative links. Rich encoding typically involves connecting new information to prior knowledge, personal experiences, or conceptual frameworks. Offloading reduces the incentive for such connections, as the external system is expected to handle storage. This leads to memories that are more susceptible to decay and interference, consistent with findings from studies on reminder anticipation and unaided retrieval (Peper & Ball, 2025).

The impact of offloading extends to learning strategies and study behaviors. Students who rely heavily on digital search may prioritize locating information over understanding it. Note-taking, summarizing, and self-explanation may be replaced by bookmarking, saving links, or trusting AI-generated outputs, particularly in digitally mediated learning environments (Lee & Lee, 2025). These strategies reduce cognitive effort in the short term but often result in weaker long-term retention. Learning becomes oriented toward task completion rather than knowledge construction.

Cognitive offloading also affects the balance between working memory and long-term memory. Working memory plays a critical role in integrating new information during learning. When attention is divided between processing content and managing digital tools, working memory resources are strained. Offloading can reduce this strain by shifting storage externally, but it may also disrupt the integration process itself, contributing to patterns of cognitive imbalance discussed in AI-supported cognition (Kabashkin, 2025).

Despite these challenges, cognitive offloading can have adaptive functions when used strategically. External tools can support learning by reducing unnecessary load, especially in complex tasks. For example, using search engines or AI tools to clarify background information can allow learners to focus on higher-level reasoning when instructional design promotes active engagement (Lee & Lee, 2025). The key distinction lies in whether offloading replaces or supports encoding. When learners actively engage with information after retrieving it, encoding can still occur.

These dynamics become more pronounced. AI systems often provide synthesized answers that require minimal user effort. While this can increase efficiency, it further reduces opportunities for active processing, as observed in studies of AI-generated annotations and academic reading (Shin et al., 2025). Users may accept outputs without evaluating underlying reasoning, leading to passive consumption of information. Memory encoding under such conditions is likely to be minimal.

Cognitive offloading reshapes how memory is formed, stored, and accessed. It alters learning strategies by shifting emphasis from internal retention to external availability. While this shift can support efficiency and reduce cognitive burden, it poses risks for deep learning and long-term retention, especially in digitally saturated environments (Say et al., 2025). Understanding these mechanisms highlights the importance of intentional engagement with digital tools. Rather than eliminating offloading, the goal should be to integrate it in ways that preserve meaningful encoding and support durable knowledge.

Adaptive vs. Maladaptive Impacts of Digital Dependency

Digital dependency introduces clear adaptive advantages in how individuals manage cognitive demands during complex tasks. Search engines and AI systems reduce the need to store large amounts of factual information internally, allowing users to focus on higher-level reasoning, interpretation, and decision-making, a pattern consistent with contemporary models of AI-supported cognition (Lee & Lee, 2025). This external support can improve task efficiency by shortening retrieval time and lowering working memory load. In learning contexts, digital tools enable rapid clarification of unfamiliar concepts, preventing cognitive bottlenecks during problem solving. Users can allocate attention to synthesis rather than recall, which can enhance performance in time-constrained environments. These adaptive outcomes are most visible when digital tools are used strategically rather than continuously. The benefits reflect an optimization of cognitive effort rather than a replacement of thinking.

Another adaptive aspect lies in the flexibility of cognitive strategies enabled by digital systems. Individuals increasingly shift between internal memory and external resources depending on task difficulty and perceived importance, reflecting patterns of cognitive offloading observed in AI-supported reading and annotation environments (Shin et al., 2025). This flexibility allows users to conserve mental resources when information is easily retrievable and invest deeper processing when tasks demand understanding. AI-supported tools also scaffold complex reasoning by organizing information, highlighting patterns, and offering structured guidance. Such support can lower frustration and mental fatigue, particularly for learners facing cognitively demanding materials. Over time, this can promote sustained engagement rather than cognitive overload. Adaptive dependency thus functions as a regulatory mechanism for mental effort.

Digital dependency also supports metacognitive regulation by shaping how individuals judge what needs to be remembered. When users know that information can be accessed later, they prioritize comprehension over memorization, a shift aligned with findings on how anticipated external reminders influence memory strategies (Peper & Ball, 2025). This shift can be productive in environments where understanding relationships matters more than recalling isolated facts. Learners may develop skills in navigation, evaluation, and integration of information rather than rote storage. In professional settings, this approach aligns with real-world problem solving that depends on access to distributed knowledge. The adaptive value becomes evident when memory is used selectively and purposefully. External tools act as extensions that complement internal cognition.

Despite these benefits, maladaptive consequences emerge when digital dependency becomes habitual and unreflective. Frequent reliance on search engines can weaken the depth of memory encoding during initial exposure to information, particularly when users anticipate effortless future access (Peper & Ball, 2025). When individuals expect immediate future access, they may engage less attentively with content. Shallow processing reduces the formation of durable memory traces, especially for conceptual and contextual details. Over time, this pattern can impair long-term retention and reduce the ability to recall information without assistance. Learning becomes fragmented rather than integrated. The cognitive system adapts to retrieval rather than storage.

Maladaptive effects are particularly evident in situations that require sustained attention and internal consolidation. Continuous interaction with digital devices introduces task-switching demands that interrupt focused processing, as demonstrated in contexts where digital media capture competes with experiential learning (Say et al., 2025). Dividing attention between documenting, searching, and experiencing content reduces cognitive immersion. Memory encoding suffers when attention is repeatedly redirected toward device management. This effect is intensified with tools that require ongoing monitoring, such as video recording or real-time AI interaction. The mental effort devoted to operating technology competes with learning-related processes. Cognitive load increases rather than decreases in these contexts.

Another maladaptive dimension involves over-reliance on external systems for decision-making and recall. When individuals defer judgments to AI outputs without verification, cognitive engagement declines, reflecting the imbalance described in discussions of AI-induced cognitive atrophy (Kabashkin, 2025). Critical evaluation skills may weaken as users accept algorithmic suggestions as authoritative. This pattern reduces opportunities for error detection and reflective thinking. Over time, confidence in internal reasoning can diminish. Dependence shifts from tool-assisted thinking to tool-directed thinking. The cognitive system becomes reactive rather than generative.

Excessive digital dependency also affects motivation to engage in effortful learning. If information is perceived as externally stored and easily recoverable, the incentive to invest in memory formation decreases, a tendency observed across technology-rich learning environments (Lee & Lee, 2025). Learners may adopt surface-level strategies that prioritize speed over understanding. This can undermine conceptual transfer and problem-solving flexibility. Tasks that require internal reconstruction of knowledge become more difficult. The gap between access and mastery widens. Cognitive efficiency in the short term produces fragility in the long term.

Adaptive and maladaptive effects do not exist as fixed categories. The same digital behavior can produce benefits or costs depending on context, frequency, and intention, a balance emphasized in analyses of AI–human cognitive interaction (Kabashkin, 2025). Strategic offloading supports cognition, while automatic offloading erodes it. The key distinction lies in whether technology is used as a tool for thinking or a substitute for thinking. Adaptive use preserves active engagement with content. Maladaptive use replaces engagement with delegation. Understanding this distinction is critical for interpreting mixed findings across studies.

Neurocognitive Implications and Directions for Future Research

Long-term interaction with digital technologies may shape neurocognitive processes through repeated patterns of attention and memory use. Cognitive systems adapt to environments that reward rapid access and external retrieval, consistent with extended-mind perspectives in AI-mediated learning (Shin et al., 2025). Neural resources involved in search, selection, and evaluation may become more dominant than those supporting deep encoding. Over time, this could alter how information is prioritized during learning. Memory systems may favor location-based or cue-based retrieval rather than content-based recall. These adaptations reflect functional reorganization rather than degeneration.

Changes in attention regulation represent a key neurocognitive implication. Frequent exposure to interactive digital environments trains the brain to manage multiple stimuli simultaneously, reinforcing patterns of distributed attention described in technology-rich contexts (Kabashkin, 2025). This can enhance scanning and switching abilities while reducing tolerance for sustained focus. Neural mechanisms supporting vigilance may become less engaged during passive information consumption. As a result, tasks requiring prolonged concentration may feel more effortful. This does not imply loss of capacity, but a shift in habitual engagement patterns. The environment shapes default attentional states.

Memory-related neural processes may also adapt to persistent offloading behaviors. When external storage replaces internal rehearsal, consolidation processes may be less frequently activated, as suggested by research on reminder anticipation and memory encoding (Peper & Ball, 2025). Hippocampal engagement during encoding may decrease for information deemed externally accessible. Instead, associative links between cues and retrieval pathways may strengthen. This supports efficient re-access but weakens standalone memory representations. The neural system optimizes for access rather than retention. Such adaptation aligns with functional efficiency but reduces independence from external systems.

AI-assisted cognition introduces additional neurocognitive considerations. Intelligent systems increasingly guide reasoning, summarize information, and suggest solutions, shaping how users internalize problem-solving structures (Lee & Lee, 2025). Repeated exposure to structured outputs may influence how individuals organize knowledge internally. Users may internalize algorithmic patterns of explanation and categorization. This can support clarity and organization but may limit exploratory reasoning. Cognitive diversity could narrow if individuals rely on similar AI-generated structures. Neural plasticity reflects repeated interaction patterns.

Future research should move beyond behavioral outcomes and examine underlying neural mechanisms more directly. Longitudinal designs are needed to track how sustained digital reliance affects brain activation over time, particularly in AI-supported learning environments (Kabashkin, 2025). Short-term experiments capture immediate effects but miss cumulative adaptation. Neuroimaging methods can clarify whether observed changes reflect redistribution of resources or reduced engagement. Studies should distinguish between task-specific adaptations and general cognitive shifts. This distinction is essential for interpreting neuroplasticity accurately.

Research should also differentiate between types of digital interaction. Passive consumption, active search, and AI-supported problem solving engage cognition differently, as shown in studies of digital annotation and media use (Shin et al., 2025; Say et al., 2025). Treating digital use as a single category obscures meaningful variation. Future studies should examine how specific behaviors map onto cognitive and neural outcomes. The cognitive cost of video recording differs from that of note-taking or annotation. Precision in categorization will improve explanatory power.

Another priority involves developmental perspectives. Young adults, adolescents, and older adults may show different patterns of adaptation due to differences in neural plasticity and learning goals, a distinction emphasized in instructional design research (Lee & Lee, 2025). Early exposure to digital offloading may shape foundational cognitive habits. Later exposure may interact with established memory strategies. Age-sensitive research can clarify whether digital dependency amplifies or compensates for developmental constraints. Lifespan approaches are needed.

Future research should adopt integrative theoretical frameworks that connect cognitive, neural, and contextual factors. Isolated models cannot explain the complexity of digital cognition, particularly in AI–human systems (Kabashkin, 2025). Interdisciplinary approaches combining cognitive psychology, neuroscience, and educational science are essential. Technology evolves faster than theory, creating explanatory gaps. Research must remain flexible and responsive. Understanding digital dependency requires studying cognition as embedded, adaptive, and context-driven.

CONCLUSION

This literature review shows that digital technologies are now tightly integrated into everyday cognitive activity, especially in how people search for, manage, and use information. Search engines and AI tools act as external cognitive resources that support reasoning and problem solving by reducing internal memory demands. Instead of replacing memory, these tools reshape decisions about what should be remembered internally and what can be accessed externally. Cognitive strategies increasingly rely on selective encoding, strategic retrieval, and contextual cues. These shifts reflect adaptation to information-rich environments rather than cognitive decline. Memory and attention are reorganized around access and efficiency.

From a theoretical perspective, the reviewed studies strengthen the concepts of outsourced cognition and the extended mind in digital settings. Cognition operates across internal and external systems, with digital tools functioning as active components of thinking. Cognitive offloading explains both improved performance and potential learning costs. A key contribution of the literature is the distinction between intentional, task-driven offloading and habitual, unreflective dependence. This distinction refines existing models by showing that technology alters cognitive control rather than eliminating it. Memory and attention models expand to include distributed, tool-mediated processes.

The review also clarifies how digital dependency affects learning. Expecting external access reduces deep encoding and weakens long-term retention, while well-timed digital support can free resources for understanding and integration. Learning outcomes depend on how technology is used during learning. Shallow use leads to fragile knowledge, while reflective use supports durable learning. Overall, digital dependency is neither inherently beneficial nor harmful. Its impact depends on usage patterns, task demands, and learner awareness, offering important insights for cognitive psychology and education in the digital era.

BIBLIOGRAPHY

Akhter, D. M. (2025). Memory in the Digital Era: Cognitive and Cultural Shifts in Remembering. *The International Journal of Indian Psychology*, *13*(2), 3796–3810. https://doi.org/10.25215/1302.336

Chirayath, G., Premamalini, K., & Joseph, J. (2025). Cognitive offloading or cognitive overload? How AI alters the mental architecture of coping. *Frontiers in Psychology*, *16*, 01–06. https://doi.org/10.3389/fpsyg.2025.1699320

Diotaiuti, P., Mancone, S., Corrado, S., De Risio, A., Cavicchiolo, E., Girelli, L., & Chirico, A. (2022). Internet addiction in young adults: The role of impulsivity and codependency. *Frontiers in Psychiatry*, *13*. https://doi.org/10.3389/fpsyt.2022.893861

Fröscher, L., Friedrich, A. K., Berentelg, M., Widmer, C., Gilbert, S. J., & Papenmeier, F. (2022). Framing cognitive offloading in terms of gains or losses: achieving a more optimal use of reminders. *Cognitive Research: Principles and Implications*, *7*(1). https://doi.org/10.1186/s41235-022-00416-3

Gerlich, M. (2025). AI Tools in Society: Impacts on Cognitive Offloading and the Future of Critical Thinking. *Societies*, *15*(1), 1–28. https://doi.org/10.3390/soc15010006

Gong, C., & Yang, Y. (2024). Google effects on memory: a meta-analytical review of the media effects of intensive Internet search behavior. *Frontiers in Public Health*, *12*(January), 1–10. https://doi.org/10.3389/fpubh.2024.1332030

Grinschgl, S., Papenmeier, F., & Meyerhoff, H. S. (2023). Mutual interplay between cognitive offloading and secondary task performance. *Psychonomic Bulletin and Review*, *30*(6), 2250–2261. https://doi.org/10.3758/s13423-023-02312-3

Jose, B., Joseph, D., Mohan, V., Alexander, E., Varghese, S. K., & Roy, A. (2025). Outsourcing cognition: the psychological costs of AI-era convenience. *Frontiers in Psychology*, *16*(December), 1–6. https://doi.org/10.3389/fpsyg.2025.1645237

Kabashkin, I. (2025). Cognitive Atrophy Paradox of AI–Human Interaction: From Cognitive Growth and Atrophy to Balance. *Information (Switzerland)*, *16*(11). https://doi.org/10.3390/info16111009

Lee, Y., & Lee, S. S. (2025). Exploring the Conceptual Model and Instructional Design Principles of Intelligent Problem-Solving Learning. *Sustainability (Switzerland)*, *17*(17), 1–33. https://doi.org/10.3390/su17177682

Meyerhoff, H. S., Grinschgl, S., Papenmeier, F., & Gilbert, S. J. (2021). Individual differences in cognitive offloading: a comparison of intention offloading, pattern copy, and short-term memory capacity. *Cognitive Research: Principles and Implications*, *6*(1). https://doi.org/10.1186/s41235-021-00298-x

Murphy, D. H., & Castel, A. D. (2023). Age-Related Differences in Memory When Offloading Important Information. *Psychology and Aging*, *38*(5), 415–427. https://doi.org/10.1037/pag0000750

Peper, P., & Ball, B. H. (2025). Anticipating a Reminder Influences Prospective Memory Encoding and Unaided Retrieval. *Journal of Experimental Psychology:*

Learning Memory and Cognition. https://doi.org/10.1037/xlm0001494

Richmond, L. L., Kearley, J., Schwartz, S. T., & Hargis, M. B. (2023). Take a load off: examining partial and complete cognitive offloading of medication information. *Cognitive Research: Principles and Implications*, *8*(1), 1–19. https://doi.org/10.1186/s41235-023-00468-z

Robert, S. J., & Kadhiravan, S. (2022). Prevalence of digital amnesia, somatic symptoms and sleep disorders among youth during COVID-19 pandemic. *Heliyon*, *8*(8), e10026. https://doi.org/10.1016/j.heliyon.2022.e10026

Rodrigues, F., Casillas-Martín, S., & Pocinho, R. (2025). Digital Entanglement: The Influence of Internet Addiction and Negative Affect on Memory Functions—A Structural Approach. *Digital*, *5*(3), 1–12. https://doi.org/10.3390/digital5030037

Say, S., Akbulut, S., & Öztürk, İ. Y. (2025). Capturing the Experience: How Digital Media Affects Memory Retention in Museum Education. *Behavioral Sciences*, *15*(9), 1–18. https://doi.org/10.3390/bs15091247

Shanmugasundaram, M., & Tamilarasu, A. (2023). The impact of digital technology, social media, and artificial intelligence on cognitive functions: a review. *Frontiers in Cognition*, *2*. https://doi.org/10.3389/fcogn.2023.1203077

Shin, B., Kang, M., Eun, S., & Cho, Y. H. (2025). Patterns of Cognitive Offloading and Extended Mind in Digital Academic Reading with AI-generated Annotations. *Proceedings of the 19th International Conference of the Learning Sciences - ICLS 2025*, *2024*, 3212–3214. https://doi.org/10.22318/icls2025.682206