OXFORD JOURNAL
OF STUDENT
SCHOLARSHIP

Cognitive offloading in the age of AI: a narrative review

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ABSTRACT

Generative Artificial Intelligence (AI) tools, such as ChatGPT are now used daily for writing, studying and decision making, raising concerns about their effect on cognition. Recently, studies have been discovering that with the increased use of AI there is also a rise in cognitive offloading. Cognitive offloading is the phenomenon in which individuals reduce their cognitive load by using external tools. An example of this is using an external file to preserve information instead of remembering it. Offloading has become increasingly prevalent, with potentially detrimental effects on cognition. This review discusses what research on cognitive offloading tells us about AI. It first summarises the established evidence on offloading memory, mostly from studies of search engines and stored notes, and then the emerging evidence on offloading thinking to AI. The established evidence shows that offloading reduces memory for the offloaded information and can leave memory open to manipulation, but also frees capacity for new learning. The emerging AI evidence suggests a further risk: when the skill being learned is itself offloaded, such as writing an essay or solving a maths problem, learning and critical thinking may suffer. However, there is still not a lot of empirical evidence on the effect of AI on cognition. Finally, the review concludes by discussing steps that individuals can take to reduce the potential negative effects of excessive offloading as a result of AI and instead use it positively.

INTRODUCTION

Artificial Intelligence (AI) has revolutionized people's lives in fields such as education, work, and medicine (Gerlich, 2025). AI refers to a machine or a system that simulates human intelligence (Xu et al., 2021) and it is meant to mimic human thought and behaviour. Since 1956, when the term AI was first coined, the technology has been through significant improvements and changes, constantly evolving and being integrated in various sectors (Padmaja et al., 2024). The topic of AI use and its risks have recently come to the attention of the scientific community, largely due to the rise of large language models, such as ChatGPT. It is also partly due to the risk of cognitive offloading.

Cognitive offloading refers to the phenomenon of using tools to reduce cognitive demands (Morrison & Richmond, 2020). This is not a recent phenomenon; people have been using tools to lessen the burden on their cognition for millennia. Since the rise of search engines, people have been using search engines and the web to not only find information, but also to fact-check information they already have. This phenomenon is known as the "Google Effect": humans using search engines as the source of information

rather than memorizing the information itself (Gong & Yang, 2024), essentially offloading memory. This can lead to less encoding of the actual information (Sparrow et al., 2011) and instead encoding of the internet address which provided the information (Gong & Yang, 2024).

AI tools differ from search engines in an important way. A search engine retrieves information that already exists, so what people mainly offload to it is storage: remembering facts. A generative AI tool also produces new text, answers questions in conversation and can make suggestions or decisions. People can therefore offload processing as well as storage: summarising, writing, reasoning and deciding (Gerlich, 2025).

This review therefore asks: what does research on cognitive offloading tell us about the likely effects of AI on cognition? Research on AI itself is recent and limited. For this reason, the review first summarises the established evidence on offloading memory, which comes mostly from studies of search engines, digital files and written notes. It then examines the emerging evidence on offloading thinking to AI, and compares them. Finally, this review also aims to provide recommendations on the steps to follow for a balanced use of AI and search engines, as well as an exploration of further research on cognitive offloading and its effects.

METHODS

This review focuses on what research on cognitive offloading suggests about the effects of AI on cognition. Websites, textbooks, and news articles were avoided and peer-reviewed journal articles were used as sources. In addition to that, there was a preprint included in this review (Kosmyna et al., 2025) because it is one of very few studies that directly compares AI, search engine and unaided writing. Primary research was the preferred type of research yet literature reviews were still used for background and definitions. All sources were from the twenty-first century; this was done to keep all of the information relatively modern, as the topic of AI and its effect on cognition is relatively recent.

Source	**Design**	**Sample**	**Measure**	**Dependent variable**	**Findings**
Bastani et al., 2025	Experimental	Nearly 1000 high school maths students	A series of practice problems with access to specific control or experimental AI tools and an exam without access to those resources	Performance on the exam and on the practice problems	Both AI tutors improved practice scores; on the exam without AI, students who had used the standard ChatGPT-style tool scored about 17% lower than students

					who never had AI, while the safeguarded tutor largely avoided this
Bouabida et al., 2026	Perspective article	This review does not include a sample	This review does not include a measure	This review does not include a dependent variable	AI serves as an augmentation to clinical physicians rather than a replacement
Gerlich, 2025	Correlational survey	666 participants	Halpern Critical Thinking Assessment	Critical Thinking Skills	AI usage is linked to lower critical thinking
Goldberg & Magen, 2026	Experimental	80 participants	Memory assessment testing recall	Number of words recalled	Participants who expected to keep their notes recalled fewer words, in both children and adults
Gong & Yang, 2024	A meta-analytical review	This review does not include a sample	This review does not include a measure	This review does not include a dependent variable	When using search engines people tend to remember where they found the information rather than the information itself
Kosmyna et al., 2025	Experiment with EEG	54 participants	Electroencephalography	Brain connectivity	The participants that switched from using large language models to using only the brain showed lower brain connectivity and engagement in certain frequency

					bands
Marcantoni et al., 2023	Systematic Review	This review does not include a sample	This review does not include a measure	This review does not include a dependent variable	Researchers do not agree on how to measure brain-wave activity using different frequency bands
Morrison & Richmond, 2020	Experimental	114 participants	Short-term memory task	Offloading behavior	Cognitive offloading can be used as a strategy to improve performance of memory-based tasks
Mushesh e & Chrispo, 2025	A conceptual study	This review does not include a sample	This review does not include a measure	This review does not include a dependent variable	The expansion of AI can challenge the cognitive integrity and the evolutionary trajectory of the human species
Padmaja et al., 2024	A concise review	This review does not include a sample	This review does not include a measure	This review does not include a dependent variable	The development of AI is of importance
Risko & Gilbert, 2016	Narrative review	This review does not include a sample	This review does not include a measure	This review does not include a dependent variable	People choose to offload cognition due to cognitive demands yet that decision is also influenced by metacognitive bias
Risko et al., 2019	Experimental	232 usable participants	Rate of false memory and a post-task	False memory	A risk of cognitive offloading is memory

			questionnaire		manipulation
Rohrer et al., 2005	Experimental	218 participants	Test-with-feedback trials	Long-term retention	Overlearning is not an effective strategy for learning for long periods of time
Shibata et al., 2017	Experimental	183 participants	Orientation detection task	Retention	Overlearning stabilizes the learning state yet it also disrupts new learning
Sparrow et al., 2011	Experimental	Different per experiment	Reaction times, recall, memory for where information was saved	Multiple dependent variables including response time	People remembered less when they expected information to be saved, but remembered where it was stored
Storm and Stone, 2015	Experimental	116 total participants across different experiments	Recall of a second word list	Recall	Saving the first list improved memory for the second; no benefit when saving was unreliable
Xu et al., 2021	Narrative review	This review does not include a sample	This review does not include a measure	This review does not include a dependent variable	The application of AI in fundamental sciences

Search and selection strategy

This is a narrative review rather than a systematic review. The main method used to identify suitable articles was the use of academic databases; in particular, the database used was Google Scholar. A keyword-driven search strategy was used to find the papers. The keywords were in an exposure and outcome format in which the exposure and outcome were entered into the database to find relevant papers. Keywords such as “cognitive offloading”, “effect”, and “memory,” were used to find studies on

the impact of cognitive offloading on memory. Keywords like "AI", "ChatGPT", "search engines", and "cognitive offloading" were used to identify research on the relation between search engines, AI, and cognitive offloading. Keywords such as "critical thinking", "learning", "essay writing" and "academia" were also used to find the effect of AI and cognitive offloading on critical thinking, learning and writing. Studies were selected to cover the main cognitive outcomes linked to offloading (memory, critical thinking, learning and writing), with priority given to experimental studies and widely cited work.

Inclusion Criteria

A study was included if it:

1. Was published in a peer-reviewed journal (or was a preprint with a significant reason for inclusion);
2. Was published in 2001 or later;
3. Measured a cognitive outcome, such as memory, critical thinking, learning or writing;
4. Involved an external tool: AI, a search engine, or a digital or paper store used as a stand-in for one;
5. Reported empirical data. Reviews were used for background and definitions only, with one exception (Bouabida et al., 2026), included as the only source on AI in clinical work.

Sorting

Included studies were sorted by what was being offloaded. Studies in which participants stored information externally (a search engine, a computer file or written notes) form Section 1 ("Established Evidence - Offloading memory"). Studies in which participants used AI to write, solve problems or make decisions form Section 2 ("Emerging Evidence - Offloading thinking to AI"). The key features of each study are listed in Table 1.

SECTION 1: ESTABLISHED EVIDENCE - OFFLOADING MEMORY

As discussed above, cognitive offloading refers to the reduction of cognitive demands required for a task (Morrison & Richmond, 2020). Examples of this include using calculators and writing down passwords (Risko & Gilbert, 2016). Humans use cognitive offloading every day to complete tasks in a simpler and easier way (Risko & Gilbert, 2016). Most research on offloading has studied memory: what happens when people store information outside their heads instead of remembering it. Most of these studies used word lists saved on paper or in computer files rather than AI. They are included as stand-ins for everyday digital offloading.

Search engines and the Google Effect

With the rise of search engines, there is a rise of external memory. The search engine allows many tools to be accessible at once. For example, if a user needs to find articles and web pages on the effect of AI on cognition, then they would simply enter a prompt and would find what they would be looking for. Because of this, there appears a phenomenon known as the Google Effect (Gong & Yang, 2024). Humans

tend to leave the information online rather than memorizing it because instead of remembering it they can rely on the internet as a source of knowledge, which can be accessed at any point via a search engine. When the search engines are so accessible, people do not think that fully encoding the information is necessary (Sparrow et al., 2011). This suggests that the use of search engines may decrease encoding and alter the memory.

Offloading reduces memory of the offloaded information

Cognitive offloading can also decrease the efficiency of children's internal memory. In a study investigating external memory aids (Goldberg & Magen, 2026), the researchers recruited 80 participants. Half of these participants were young adults and the other half were children. The researchers split the experiment into four blocks. In the first block, the participants were given a 20-word-list to memorize without an external memory. The researchers then gave them two minutes to recall as many words as they could, during which the researchers noted their response. The participants' response during the test was oral. In blocks two and three, the participants were familiarized with offloading. They were given a sheet of paper to write the list of words on. For about thirty seconds, they were not allowed to look at their notes. They were then instructed to use the notes to answer the questions on the test. They did this by writing down their responses on a second sheet of paper. In the fourth block, participants were able to write down the words on a sheet of paper. The participants were then split up into two groups. The first group was told that their notes would not be available to them during the test. The second group had the same condition yet they did not know about the condition until right before the test. The responses during the test were required to be oral. The results of the test in the first block showed that the adults did better than the children in recall. The results of the second and third test were very similar since both groups had the ability to use their notes. In the fourth block, participants who expected to keep their notes recalled significantly fewer words than participants who had been told in advance that their note would be taken away, and who therefore memorised the words themselves. This cost appeared in both age groups: there was strong evidence for it in children as well as in adults, and the difference in its size between children and adults was not statistically significant. Participants who expected to keep their notes also reported using fewer memory strategies, such as repeating the words or linking them into a story, and this difference was significant for both children and adults. Because children already recalled fewer words than adults in the first block, this comparison between the two groups, rather than the age difference alone, shows whether offloading reduced internal memory, and whether it did so more for children. This shows that offloading reduced internal memory in both children and adults.

Offloading leaves memory open to manipulation

Offloading memory may leave us vulnerable to memory manipulation. A study by Risko et al. (2019) investigated the effects of this phenomenon. The study was organized into three experiments. The first experiment allowed the participants to type the four word lists given to them into a document. The participants then performed a distraction task that took their mind off of the list. Participants were then shown words and were asked if those words were on the initial list. During the final trial, an additional word that was not included in the initial list was added to the document. The participants were also asked to share how confident they were when recalling that additional word. While the inserted word did not

appear in the initial list, but was added later, participants often accepted the word as one they had studied, since it was in the document and they maintained access to the list during the test. This is an example of memory manipulation, since the inserted word was accepted simply due to the fact that it appeared on the document, even though the participants themselves did not add it. The second experiment attempted to show whether these inserted words would be recognized by participants without the use of an external document. The second experiment was almost identical to the first one, but during the final test the external document was taken away. Participants were still allowed to access the external document with the inserted words in it before the test. Similarly to the first experiment, participants were then asked whether the inserted words were on the lists. For about 60% of the time, the participants agreed that the words were on the original lists. This suggests that participants may place more trust in external tools compared to their own memories. It also suggests that there was a failure to accurately evaluate the information listed on these tools. In the third experiment, participants were also shown word lists with inserted words. They then ranked how confident they were in recognizing the word. During the first test they were given access to the external document. However, on the next recognition test the external document was removed. When the external document was allowed to be used on the test, participants thought the inserted words were on the list around 80% of the time. Without the external memory, participants guessed the inserted words were on the list around 45% of the time. Together, the experiments show that external memory tools can influence one's own memory, even after the tool is removed.

Offloading can free capacity for new learning

Offloading can also have benefits. Reduced cognitive demands allow people to divert their capacity to another task. Storm and Stone (2015) asked participants to study a computer file of words (File A), then either save it or close it without saving, and then study a second file (File B). Participants remembered File B significantly better when they had saved File A first. The benefit disappeared when participants believed saving was unreliable, or when File A was too short to interfere with memory for File B. This shows how cognitive offloading can be useful by allowing an individual to switch tasks or learning material more efficiently, as it decreases cognitive demands.

Possible effect of cognitive offloading on overlearning

A possible, but untested consequence of offloading is reduced overlearning. Overlearning refers to the act of practicing a skill beyond a perfect instance (Rohrer et al., 2005). For example, most people learn simple writing and language skills to the point that they become automatic. A study conducted by Shibata et al. (2017) sheds more light into how overlearning works. The findings showed that overlearning leads to changes in the ratio of the excitatory glutamate to the inhibitory gamma-aminobutyric-acid. The experiment showed that when participants learned something without overlearning, their glutamate to GABA ratio was significantly higher than the pre-learning ratio. However, after 20 minutes of overlearning, the glutamate to GABA ratio was significantly smaller. This showcases how overlearning works: the participants that overlearned the material were able to retain that knowledge even after another task, as overlearning stops the process of other learning replacing the former learning, allowing the original knowledge to be stable. Generally, this process allows learning to be resilient against the learning

of the future, allowing that knowledge to reach a permanent state. This resistant process of overlearning allows the information to "sink in". Cognitive offloading can possibly decrease the practice that is needed to master certain skills, which could lead to a decrease of overlearning. Overall, it is important to note that this relationship is not discussed in this study yet this might become an avenue for future research even though it is not established.

SECTION 2: EMERGING EVIDENCE - OFFLOADING THINKING TO ARTIFICIAL INTELLEGENCE

Generative AI allows people to offload not just facts but whole tasks: writing, problem solving and decision making. Research on this is still limited, so this section contains emerging evidence.

AI use and critical thinking

A consequence of using AI to reduce cognitive demands in a variety of tasks is that we resort to AI for decision making. This also affects our opportunities to practice critical thinking. A study by Gerlich (2025) investigated the effect of offloading on critical thinking. In the study, participants were split up into three groups, according to age: young, middle-aged, or older. They were then given a questionnaire that asked them about their age and gender, their AI use, their use of cognitive offloading, and finally a critical thinking analysis. The results showed that the younger age group showed substantially more use of AI and evidence of cognitive offloading; this was paired with a lower critical thinking score. The older group showed quite different results: participants used AI less and did not offload as much; they also achieved a higher critical thinking score. These findings show that greater AI use is associated with lower critical thinking. Because the study is a survey taken at one point in time, it cannot show that AI use causes lower critical thinking. The study also showed that more educated and older participants also participated in more deep-thinking activities. Participants were also told to disclose their occupation, which showed that people in managerial roles exhibited more critical thinking. This study suggests that even though artificial intelligence can do tasks that require critical thinking, it is still crucial to maintain a balance, since excessive use could result in a decrease of critical thinking skills.

AI and essay writing

Another area in which AI is being used to simplify tasks is academia (Musheshe & Chrispo, 2025). People use AI every day to write essays, correct grammar, and even conduct research, essentially offloading their work to an AI assistant. In their study, Kosmyna et al. (2025, preprint) explored the effects of LLM and search engine usage in essay writing and the effects of artificial intelligence on the brain. They used electroencephalography (EEG) to map brain activity and 54 participants were split into three groups. The first group was classified as the LLM group, and the other two as the search engine group and the brain-only group. These groups had to write an essay using their designated tools in three sessions, followed by a fourth session completed by 18 participants. During the fourth session, the LLM group switched tools with the brain-only group. The EEG analysis showed that more external aid correlated with lower brain connectivity. The brain-only group showed wide ranging networks and the LLM group showed the weakest connectivity. These analyses were taken during the first three trials.

During the fourth trial, the participants who switched from LLMs to brain showed under-engagement of alpha and beta networks. According to the researchers, the brain-to-LLM group showed higher memory recall and re-engagement of the occipito-parietal and prefrontal nodes (Kosmyna et al., 2025). For the LLM-to-brain group, the under-engagement of the alpha and beta network implies that they were not actively using the alpha and beta networks. The beta network is 13-35 Hz and is associated with an active mind and external attention, while the alpha network is 8-12 Hz and is associated with resting and passive attention (Marcantoni et al., 2023). The LLM group had a lower ability to quote from their essays that they had just written and the LLM group also had a lower reported level of ownership over their own essays (Kosmyna et al., 2025). This is the only study in this review that compares AI and search engines directly. The search engine group fell between the other two groups, suggesting that AI reduced engagement more than search does. However, the study is small, has not yet been peer reviewed, and the fourth-session results rest on only 18 people, so its conclusions should be treated as early evidence.

AI and learning in school

Bastani et al. (2025) ran a field experiment with nearly a thousand high school maths students. Students practised with one of two AI tutors: a standard ChatGPT-style interface (GPT Base), or a version with prompts designed to protect learning (GPT Tutor). A control group practised without AI. AI access improved performance during practice. However, when access was taken away for the exam, students who had used GPT Base did worse than students who never had AI, with grades about 17% lower. The negative effect was largely avoided with GPT Tutor. The authors concluded that, without safeguards, students used AI as a crutch during practice and then performed worse on their own. Because students were randomly assigned and the sample is large, this is the strongest evidence in this review that offloading to AI can harm learning, and it also shows that the harm depends on how the tool is designed.

AI in medicine

Artificial intelligence can also have a positive impact within fields like medicine, especially in clinical settings. A recent review by Bouabida et al. (2026) argued that AI should be an extension rather than a replacement for medical professionals. More specifically, AI can review literature, spot guideline updates, flag safety signals, and synthesize patient data. It can also help professionals access relevant information more efficiently, while reducing the time needed to search for data. The study explained that offloading work to AI can help professionals divert their time to something else, suggesting that AI can enhance and support human judgement rather than replace it. AI can also contribute to the medical field by helping physicians navigate an era where there is a wealth of available information. It is also important to note that current educational models are not keeping up with the information environment, as they are poorly suited for an era where knowledge is changing rapidly. They are not a good fit for the clinical landscape which constantly evolves because of evidence generation, diverse data quality, and rapid guideline changes. However, there can also be challenges when implementing AI into medicine. For example, AI can lead to the widening of the difference between high-resource institutions and low-resource institutions: if institutions are forced to depend on AI, low-resource institutions may not be able to keep up with high-resource institutions. In any case, the authors emphasise that AI can be a valuable tool if

used appropriately. It has the potential to help clinicians achieve excellence and preserve patient safety while making ethical decisions. Overall, this is a review that puts forward an argument, not an experiment, so it shows how AI offloading could help clinicians rather than measuring whether it does.

DISCUSSION

This review explored the effects of the use of artificial intelligence on cognition, from the lens of cognitive offloading. Read together, the two sections point to one pattern. Offloading reliably reduces memory for whatever is offloaded (Sparrow et al., 2011; Goldberg & Magen, 2026), but it frees capacity for other tasks (Storm & Stone, 2015). This trade is usually harmless when the offloaded information is not the thing being learned. The clearest harm appears when the offloaded task is the skill itself: students who let AI write their essays remembered less of them (Kosmyna et al., 2025) and students who let AI solve maths problems did worse when AI was removed (Bastani et al., 2025).

This pattern also explains why AI may be riskier than search engines. A search engine mainly takes over remembering facts, which is the kind of offloading the first section of this review found often has a benefit. AI can also take over writing, reasoning and deciding, which are often skills a person is trying to learn. The one study that compares the two directly found lower brain activity with AI than with search (Kosmyna et al., 2025), though the study was small and not peer-reviewed.

The strength of evidence is uneven. The best evidence for harm from AI comes from a large randomised experiment (Bastani et al., 2025). The critical thinking findings come from a survey that can only show an association (Gerlich, 2025) and the brain activity findings come from a small preprint (Kosmyna et al., 2025). Most of the memory studies used word lists on paper or in files, which are simpler than real AI use. The conclusions should therefore be seen as well supported for memory, and as early but consistent for AI.

Two further findings suggest that harm is not inevitable. Bastani et al. (2025) found that an AI tutor designed to give hints instead of answers largely avoided the learning loss. Storm and Stone (2015) found that offloading only helped when people trusted the tool, while Risko et al. (2019) showed that trusting a tool too much makes memory easy to manipulate. Together, these suggest that how a tool is designed and how much people trust it may matter as much as whether they use it. Offloading can also relieve people of work that may not be of critical importance, such as scheduling or sifting repetitively through data, as Bouabida et al. (2026) argue for clinicians, creating more time for important decisions or human interaction.

Recommendations

How can people attempt to use cognitive offloading positively and limit its negative consequences? Based on the pattern above, the key is to avoid offloading the skill being learned. People should embrace any opportunity to critically think and problem-solve, using search engines or AI only to further refine their work. This strategy of attempting to complete the task independently first would encourage people to rely

on their skills, turning to AI or search engines for help only if needed. Importantly, this strategy is also relevant in education, since cognitive offloading has been linked to reduced internal memory processing in children (Goldberg & Magen, 2026). Educators could also choose AI tools designed to guide rather than answer, like the GPT Tutor in Bastani et al. (2025). Limiting AI use, and therefore cognitive offloading, allows educators to prioritize critical thinking and decision making.

Future research

More experimental and long-term studies of AI use are needed, since most current AI evidence is correlational, short-term or not yet peer reviewed. Future research might be able to further explore the effect of cognitive offloading on brain structure. Regular use of external tools such as search engines may be associated with structural changes in the brain, including the creation of new connections in the brain's synapses (Gong & Yang, 2024). These tools may also alter the brain's gray matter density, which can influence how people interpret and interact with transactive memories (Gong & Yang, 2024). An example of this type of external reliance is repeatedly using search engines to find information when needed. As a result, people may remember where the information is stored rather than the information itself (Gong & Yang, 2024). Because AI responds like a conversation partner, it may become part of people's transactive memory systems in a way that search engines do not, which is another question for future research. Finally, the possible link between offloading and reduced overlearning has not yet been tested.

CONCLUSION

This review explored the effect of artificial intelligence on human cognition, using research on cognitive offloading as its starting point. Established research shows that offloading memory weakens memory for the offloaded information but frees capacity for other tasks. Emerging AI research suggests a greater risk when people offload the very skills they are trying to learn, such as writing or problem solving, though some of this evidence is still preliminary. The current review, therefore, stresses the importance of recognizing that AI is not always beneficial or harmful, but rather has nuanced effects that depend on what is offloaded and how the tool is designed.

LIMITATIONS

The present review has certain limitations. First, it did not examine all of the relevant papers, due to time constraints, and searches used only Google Scholar, so relevant studies may have been missed. As this was a narrative rather than a systematic review, it might have not captured all relevant research. At the same time, due to the fact that the field of artificial intelligence and large language models is still in its infancy, more information is surfacing at a rapid pace. Since this field is constantly evolving, the findings included in this review may not represent all of the relevant information. Second, most of the memory studies used word lists stored on paper or in computer files. These are stand-ins for AI use: they capture storing information, but not the conversational and generative use of AI, which may affect how people use and trust it. Third, the AI evidence includes a correlational survey (Gerlich, 2025) that cannot

establish cause and a preprint that has not yet been peer-reviewed (Kosmyna et al., 2025), which was included because it is one of the few studies to compare AI and search engines directly.

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