

Can a memory still exist and be retrievable even if it's forgotten?

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ABSTRACT

The scientific understanding of memory has changed substantially over the past centuries. It has shifted from the philosophical disputes of Plato and Aristotle to the more biologically evident case of patient H.M. Early experiments on various cases have helped shape the fundamental principles of memory, resulting in multiple definitions and theories. In the early 1800s, many people believed that memory loss came from a sickness, but they eventually recognized it had a partial correlation to the brain. In the 20th century, groundbreaking evidence came with the curious case of H.M. (Henry Molaison), who underwent brain surgery to treat his severe epilepsy. Surgeons removed large portions of his medial temporal lobes, which caused memory impairment. This case eventually led scientists to posit the Standard System Consolidation Theory (SSCT), which proposes that newly encoded memory forms at the hippocampus but gradually becomes stored in neocortical systems. For decades, SSCT became the accepted explanation for memory loss and retrograde amnesia. However, more recent research has questioned this framework. Theories like the Multiple Trace theory (MTT) or Contextual Binding Theory (CB) suggest that the hippocampus is required for long-term memory retrieval.

These theories suggest that there are many broader factors for memory loss, such as context, the time the memory was formed, and the patient's health. This review traces the historical development of memory theory, evaluates whether contemporary evidence supports a traditional system consolidation theory or a context-based alternative (CB and MTT), and makes an approach to tackling explanations for memory loss.

Keywords: Memory, Consolidation, Retrieval failure, Storage failure, Amnesia, Hippocampus, Neocortex

INTRODUCTION

The question of whether memory can continue to exist even when it cannot be consciously retrieved continues to intrigue many scientists. Forgetting is considered a universal action, yet it is truly unclear whether forgotten memories are permanently lost or just inaccessible. In history, early thinkers such as Plato and Aristotle debated the nature of knowledge and recollection. While Plato debated that memory was a process of recollecting eternal knowledge possessed by our souls, Aristotle argued that memory

arose from our sensory experiences, grounding it more in our human biology (Shen, n.d.). Aristotle's ideas are more prominent in studying memory today, as our biology plays a clear role in determining the formation of memory.

In the late 19th century, memory was viewed much differently. For example, Ribot (1881), a pioneering French psychologist, suggested what is more similar to a modern interpretation of memory: he believed that amnesia was caused by neurological injury or psychological trauma. This started to make us question the functions of different brain regions. Building on this, early twentieth-century researchers began investigating how memory was organized in the brain (Squire & Wixted, 2011). Lashley (1929) proposed that memory is distributed throughout the cortex and that the contribution is equal throughout all regions. In contrast, Hunter (1930) and Hebb (1949) supported that memory storage is indeed distributed but that different areas store different functions and features, a perspective that aligns more closely with present-day theories.

A major turning point then came in the case of Henry Molaison (H.M.) in 1953. After a surgical removal of his medial temporal lobes to treat his epilepsy, H.M. developed anterograde amnesia, but his intelligence and past memories were intact (Scoville & Milner, 1957). These findings revealed that the fundamental principle of memory is a distinct cerebral function, separable from other perceptual and cognitive abilities (Squire & Wixted, 2011). It furthermore identified that the medial temporal lobe was important for the formation of newer memories, as H.M. could not make new memories and only retained his older memories. H.M.'s case led researchers to reconsider the nature of amnesia itself, as they started viewing amnesia as not a single, uniform condition, but rather as many different conditions based on the distinct impairments to memory and their causes (Squire & Wixted, 2011). One important distinction is between retrograde and anterograde amnesia. Anterograde amnesia is the inability to form new memories after a brain injury that caused the amnesia, while retrograde amnesia is the loss of memories before the brain injury (Squire & Wixted, 2011). For example, patient H.M. had anterograde amnesia as he could remember everything before the surgery, like his childhood memories, but nothing after the surgery. These two different amnesias also suggest that memory formation and memory storage may rely on different neural mechanisms and different regions of the brain. This observation has since led to more debates about how memories are formed and stored.

Beyond these distinctions of amnesia and their types, researchers also began identifying multiple forms of memory. For example, declarative (explicit) memory, which concerns conscious memories for facts and events, depends on the medial temporal lobe. On the other hand, nondeclarative (procedural) memory refers to unconscious memories for skills expressed through performance, which are specifically learned and strengthened through hours of practice. Non-declarative memories may include skills, habits, conditioning, perception, etc (see Fig. 1 for a full classification breakdown). Another classification of memory is immediate and working memory. Patient H.M. had spared immediate memory, but his working memory was affected by his surgery. More specifically, in a digit span test, H.M. was able to recall up to 7 digits; past 7 digits, H.M.'s working memory was engaged, and his performance deteriorated. These

different distinctions of memory further complicated the question of what it means for a memory to truly “exist.”

Additionally, a central theoretical debate emerged between explanations of memory loss based on storage failure versus retrieval failure. Storage-based failure proposes that forgetting happens because the memory itself has deteriorated or been disrupted within our neural networks. Following this perspective, if cerebral organs were unable to store the memory, it would be considered permanently irrecoverable. In contrast, a retrieval-based memory loss framework claims that memories may still be stored in the brain even if we cannot consciously access them. According to this standpoint, forgetting indicates an issue in the processes required to locate, activate, or reconstruct already stored information. This struggle can result from various factors, such as contextual changes, damage to parts of the brain, or weakened connections to trace the memory. Memory retrieval failure implies that memories still exist and may be retrievable (Umanath et al., 2023).

This debate raises a fundamental question: when a memory cannot be consciously retrieved, has it been erased from the brain’s memory storage, or is it just simply inaccessible under current technological advancements and conditions? This distinction is crucial as it formulates how researchers interpret memory loss and the different conditions of amnesia. Understanding whether forgetting reflects a complete destruction of lost memory or temporary inaccessibility to the memory would help us develop future models of memory and guide treatments for memory loss. Therefore, this review aims to trace the historical development of memory theory, examine key neurological experiments as evidence, and evaluate whether any of these findings better support a plausible answer to “Does a memory still exist even if it's forgotten?” By combining our current knowledge, different explanations of memory loss and modern neuroscience evidence, this paper seeks to clarify whether memories truly disappear – or whether they can be retrieved.

METHODS

To identify relevant literature, web searches were conducted using Google Scholar and PubMed, which were selected for their vast coverage of neuroscience, psychology, and cognitive science research. Search terms included keywords such as “memory theory”, “consolidation”, “retrieval failure”, “storage failure”, “experimental”, and “forgetting,” used individually in combination to capture both theoretical and experimental work. The aim of this research was to provide context on the current state of memory research, ultimately determining whether forgotten memories can be retrieved in some way. This requires the paper to discuss the historical background of research in memory, whilst providing an idea of current theories for memory. Experiments were used as evidence to prove which ideas of memory may be true.

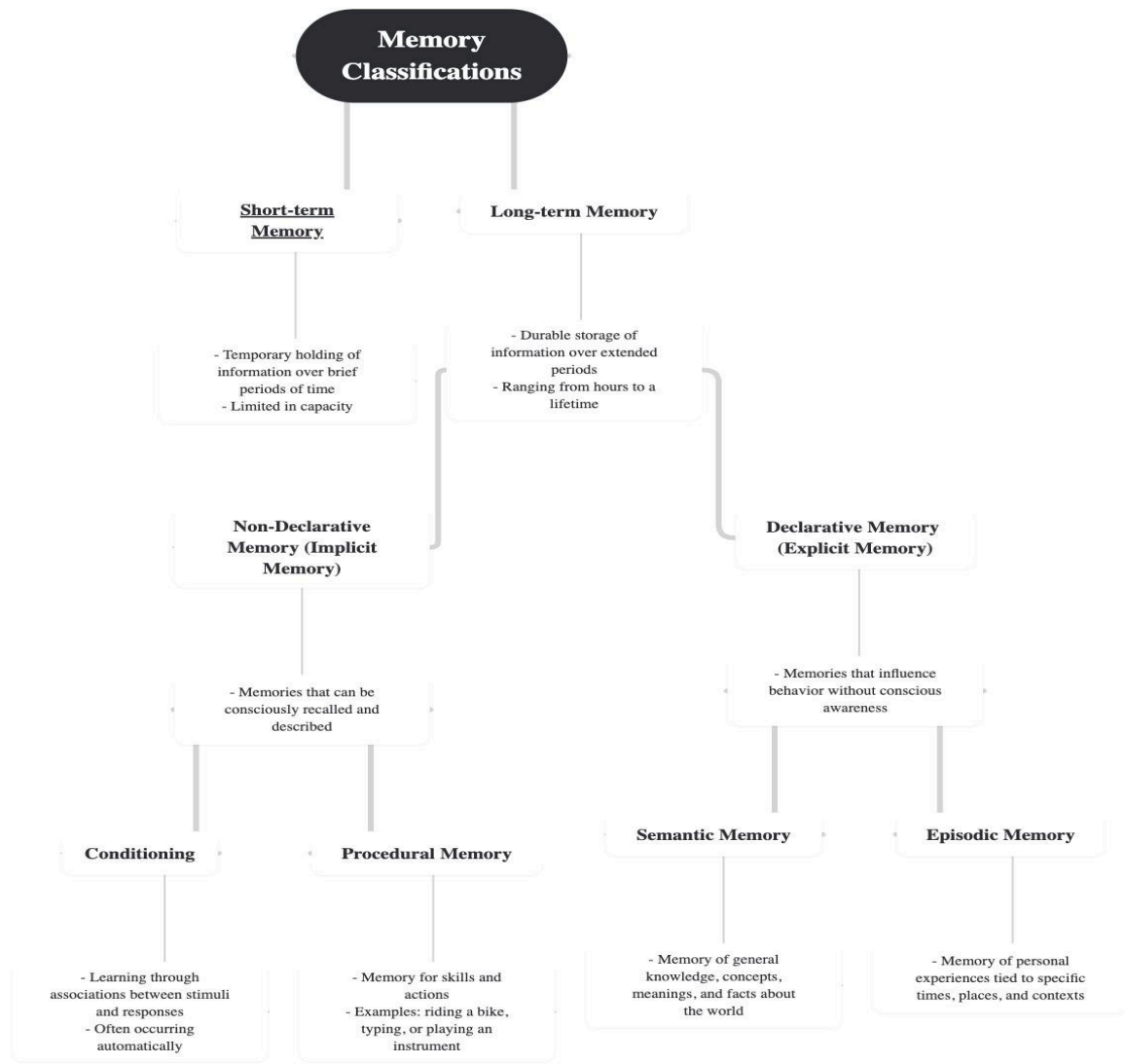
The search began with the classic and most established framework, memory consolidation theory, in order to establish a baseline understanding of how memories are thought to be stored and stabilized over time. From there, the search was expanded to identify newer and competing theories, such as multiple trace theory and contextual binding theory. This allows for a wider variety of perspectives and more recent

alternative explanations. Next, searching for evidence for whether a memory could still exist through experimental papers, and also whether the memory consolidation theory still stands. Priority was given to papers that directly discussed the debate between retrieval failure and storage failure as explanations for forgetting, including foundational case studies, theoretical papers, and empirical research using neuroimaging and behavioral measures. Finally, a conclusion moving forward was provided based on the research conducted.

LITERATURE REVIEW

1. Different memory classifications

Understanding whether memories are lost or simply inaccessible first requires a clear framework of the different categorizations of memory. Traditionally, memory is divided into short-term memory and long-term memory. Short-term memory refers to the temporary holding of information over brief periods of time and is limited in capacity. In contrast, long-term memory refers to the more durable storage of information over extended periods, ranging from hours to a lifetime. Long-term memory may be further divided into declarative and non-declarative memories. Declarative memory includes episodic memory, which connects personal experiences to specific contexts, and semantic memory, which covers general knowledge and facts. Non-declarative memory includes procedural skills and conditioning, which are forms of memory that work without conscious awareness. These distinctions provide a useful framework for examining how different types of memories may be affected in various injury situations and cases of memory loss.



[Figure 1: Mindmap of Memory Definitions](#)

Fig. 1. The mindmap above illustrates the classification of memory, beginning by dividing memories into short-term and long-term memories. It then further divides into non-declarative (implicit) memory and declarative (explicit) memory systems. The bolded lines represent connections between the different memory classifications, while the unbolded lines define these classifications. This figure provides a clear visual overview of how these classifications are organized based on their defining characteristics.

2. Memory Consolidation Theory

Memory consolidation is the process through which recently acquired information (short-term memory) gets transformed into long-term memory. This theory, which is widely accepted, is the foundation of

many memory theories and plays an essential role in determining whether memories are permanently stored or whether they could ever become lost. Instead of the instant storage of memories, as it may seem, they undergo a certain consolidation process that consists of the enhancement and organization of memories.

There are two distinct stages in this consolidation process: cellular consolidation and systems consolidation. The former occurs rather fast and involves physical changes at the neuronal level, which include synaptic strengthening. In contrast to cellular consolidation, systems consolidation occurs much later and involves changes in interactions among various brain regions.

In the standard memory consolidation theory, the hippocampus plays a central role in this process. Located in the medial temporal lobe, it is especially important for forming new episodic memories (episodic memory being a subtype of declarative memory, as outlined in Fig. 1). As an event occurs, various sensory components of the experience, such as vision, sound, or emotions, are processed in different regions of the brain. In this sense, the hippocampus serves as a mediator/coordinator of this process and integrates all of these aspects into one memory. Without its help, it is difficult to form new memories, for example, in patients like H.M.

Next, it has been thought that, over time, memories become independent of the hippocampus and are gradually relocated to the neocortex, where they are stored more permanently. This claim is supported by observations from patients with retrograde amnesia, such as H.M., where people tend to forget their most recent memories, while the older memories remain fully present. This tendency indicates that recent memories are still unstable and depend on the hippocampus, whereas older memories do not. Thus, it is implied that these older memories are stored somewhere else in the brain.

Nonetheless, this theory is not wholly supported. There have been several studies indicating that even older memories – particularly those which are highly detailed and personal — do require the hippocampus for their retrieval. For instance, in the case of H.M., it was observed that with age, older memories became more factual and lacked detail. This suggests that there is a possibility that the hippocampus plays an ongoing role in the retention of rich and contextually detailed memories. However, it is likely that the interpretation could be restricted and complexified due to variables like age-related deterioration of the brain and diminished rehearsal, which would make it hard to conclude that these changes can only be associated with damage to the hippocampus. Nonetheless, the observations contradict the concept that older memories do not depend on the hippocampus anymore.

According to reactivation theory, when an experience occurs, different features of that event — such as visual details, sounds, and spatial context — are processed in separate cortical regions. In other words, remembering implies reactivation of all these particular parts. This hypothesis is proven by such neuroimaging studies, showing that the activation of various regions is similar for encoding and retrieving. Therefore, the role of the neocortex is not limited to simply receiving memories from the hippocampus, but rather also to actively store specific components of them. Further evidence for this

hypothesis comes from cases of neurodegenerative disorders. For example, patients with achromatopsia cannot perceive or recall color, those with prosopagnosia cannot recognize or remember faces, and individuals with amusia struggle with musical memory (Squire & Wixted, 2011). As these cases show that damage to the particular cortical regions influences the processes of perception and memory, it proves that memory storage is closely related to the original regions of processing within the neocortex.

Apart from understanding the locations of where memories may be stored, researchers have also explored how memories are experienced during retrieval. One important difference would be between recollection and familiarity, where recollection would be considered the retrieval of certain contextual details, while familiarity is the sense that an item was encountered before (without any details). Initially, it was believed that recollection and familiarity were done by different parts of the medial temporal lobe. However, recent studies have argued against this. Studies with patients with hippocampal damage show impairments in both recollection and familiarity, suggesting its contribution to these processes (Squire & Wixted, 2011). From this, we can infer that retrieval processes are not just the work of a singular system for a different process, but multiple systems working together to carry out retrieval processes.

Thus, from all these observations, we can conclude that memory is distributed, complex, and dependent on specific situations and interactions between neural pathways. This further complicates whether a memory can truly be recovered even though we forget it.

3. Different memory theories

Building on these different classifications, researchers have proposed various other theoretical explanations of how memories are stored and retrieved. Central to these discussions is the process of memory consolidation, whereby the newly encoded information is transformed into stable long-term memories. This theory is widely regarded as one of the more well-known theories for memory storage and argues that consolidation involves coordinated activity between the hippocampus and distributed neocortical networks. There are also a vast number of theories, such as multiple trace theory (MTT) and contextual binding theory (CB), that argue and go against memory consolidation theory.

MTT argues that long-term memory is formed because a neural network is strengthened if the memory is constantly recalled and remembered. In addition to that, according to MTT, episodic memories are always dependent on the hippocampus, no matter how old, indicating that older memories should have a more distributed hippocampal activity. This theory states that every single time a memory is recalled, it is within a slightly different context, and a new version of this memory is made. The more versions/copies of a memory are made, the stronger the memory becomes. If the hippocampus is damaged, recent memories are more likely to be lost compared to remote memories because remote memories have more traces and are more widely distributed in the neocortex (Sutherland et al., 2020). Eventually, semantic memories (see Fig. 1), a form of declarative memory distinct from episodic memory, become independent of the hippocampus.

Human studies provide important evidence for evaluating these claims. One such observation has come from individuals with bilateral hippocampal damage (Sutherland et al., 2020). Such patients have difficulty in recalling both recent and remote episodic/context memories. This indicates that episodic memories are not completely transmitted into the neocortex over time, as the hippocampus may still play a significant role in their retrieval. Supporting evidence is further found through studies conducted using the fMRI, an MRI scan that is used to measure blood flow, determining brain activity. When the brain performs memory retrieval, the hippocampal region is activated during both the recollection of recent and remote memories, reinforcing the idea that the hippocampus is necessary for episodic memories. However, further investigation has also shown that recent and remote memories may be associated with different areas of the hippocampus, with recent memories related to anterior areas and remote memories related to posterior areas. This stipulates that the location of memory representations may alter within the hippocampus over time.

The process of memory consolidation is, however, more nuanced. Researchers assert that the activation of the hippocampus during memory recall might not necessarily affect the storing of memory traces (Yonelinas et al., 2019). Furthermore, they believe that such hippocampal activation reflects the brain's spatial processing (processing the memory based on the situation), rather than forming a new trace. In other words, there is a possibility that ongoing hippocampal activation indicates a more normal cognitive function rather than fully supporting memory consolidation.

The Contextual Binding theory, CB theory for short, offers another explanation of consolidation, which states that episodic memories are reliant on the hippocampus throughout life and do not migrate to the neocortex. According to CB theory, the hippocampus functions by binding together the different components of an experience, such as what happened, when and where it happened, our emotional state during the event, and surrounding environmental details. This binding process is what allows participants to recall these memories in rich detail. Unlike standard consolidation theory, which proposes that forgetting happens when consolidation fails, or memories are not successfully transferred to the neocortex, CB argues that forgetting happens due to contextual interference. In other words, if you experience similar events a lot of times, there will be a lot of different scenarios with similar but different contexts, leading to forgetting specific events. Because recalling requires a reconstruction of the context of the event, memories are harder to access and recall, even though the memory trace may still exist.

CB also emphasizes that the context bound to a memory happens right before the event, during the event, and after the event takes place. This helps explain why events that happen shortly before or after learning can hinder recall. It is mainly supported by how context improves retrieval and how too much context may lower the accuracy of our recall. It also provides an explanation of how sleep helps us remember better. During sleep, individuals are no longer encoding competing information, reducing contextual interference (Yonelinas et al., 2019).

Although CB theory provides an explanation for several memory-related processes, it is not comprehensive. One limitation is that it places strong emphasis on contextual interference, yet some

forgetting may happen when the context is stable, suggesting a biological or neural decay. This suggests that some forgetting may occur due to memory becoming physically weaker over time. This may be caused by aging or damage in the area. In addition, CB fails to explain why older memories may be recalled after hippocampal damage. Therefore, CB may be useful, but it may not account for every single instance of memory loss.

Taken together, these three frameworks offer distinct but incomplete accounts of memory storage and retrieval, leaving the debate largely unresolved due to conflicting evidence and methodological differences. Nadel et al. (2007) directly compared and tested consolidation theory against multiple trace theory, using neuroimaging, neuropsychology, and animal subjects, concluding that “the empirical data are not fully consistent with Standard Consolidation Theory” and the overall weight favors MTT instead. However, they also found that support for MTT is considerably stronger in neuroimaging studies than in neuropsychological studies, illustrating how conclusions about these theories can shift depending on which method is used. Even so, Nadal et al. (2007) acknowledge that MTT’s own proposed mechanism for continued hippocampal involvement, in which each retrieval creates a new memory trace, was not consistently supported by later evidence. This shows that no single theory is more right than the others; they can be used as frameworks to visualize these abstract concepts. Contextual Binding theory adds another layer to this discussion by proposing that forgetting largely results from contextual interference (Yonelinas et al., 2019) rather than from a failure of either storage or transfer. CB is especially useful for explaining things that consolidation theory and MTT don’t really address, like why sleep seems to help us remember better. CB explains that this is because when you sleep, there is less context to interfere with your memories, thus preserving them. This view helps account for evidence that memory loss can occur without any measurable biological deterioration, but it does not fully explain cases in which forgetting persists even when the context remains intact and unchanged. Because these theories are frequently tested using different techniques and memory types, and because even their strongest proponents acknowledge unresolved inconsistencies within their own framework, no single theory has been able to account for the full range of available evidence. This lack of convergence reflects the broader theoretical debate discussed throughout this review and helps explain why the question of whether forgotten memories exist remains unresolved.

4. Evidence from Studies

Studies in the field have evaluated different theories about memory, such as memory consolidation or retrieval against storage failure. While previous theories were based on behavioral observations, advances in neuroimaging allow us to delve deeper into the processes of memory formation. These advances in technology also provide us with some insight into the root cause of memory loss and whether it is truly lost or could be retrieved. By analyzing evidence from both human and animal experiments, current modern research offers a more grounded perspective on whether memories can still exist even when they cannot be consciously recalled.

Moreover, recent research has started challenging conventional views of the forgetting process. According to Ryan and Frankland (2022), forgetting should be viewed as not simply a storage failure of memories but a retrieval failure. Their research focused on engram cells, which are specific groups of neurons activated during learning that store a physical trace of memory. Using modern techniques of optogenetics, chemogenetics, and early gene tagging, researchers were able to identify, label, and later reactivate the neurons involved in a learned memory. In one important experiment, mice underwent fear conditioning, where they learned to associate a particular context with a mild electric shock. After the experiment, the researchers injected drugs to cause amnesia in the mice. Naturally, the mice appeared unable to remember the fear memory when placed back into the environment. However, when the scientists directly stimulated the original engram cells from the fear conditioning, their memories were regained, and they showed fear responses. The scientists also found out that the engram cells became inaccessible, meaning the brain could no longer reactivate them using natural cues. More importantly, their research showed that forgotten memories could still be recovered through direct stimulation of these cells, supporting the existence of the memory trace itself. This research is important because it suggests that, in many cases, memories can still be retrieved even when they feel nonexistent. This also gives us something to look forward to, as it gives us hope that we may be able to retrieve lost memories with some special form of treatment or memory cues.

Another line of experimental evidence comes from studies using the Think/No-Think paradigm, which investigates whether actively suppressing a memory can lead to forgetting. In a study by van Schie et al. (2023), two experiments were conducted using this paradigm. In the first experiment, participants learned singular Dutch word pairs and were split into two groups: the “suppress” group and the “press spacebar” group. The “suppress” group was tasked with intentionally trying to avoid remembering the conjugate pair of a word, while the “press spacebar” group was tasked with just pressing the space key to distract them from remembering the conjugate word pair. The participants were then given a cue and had to use trial and error to determine whether to respond to or inhibit the conjugate pair, as they received no instructions on the appropriate response. Both groups demonstrated comparably higher forgetting of words that had been suppressed or interfered with on a final memory test than of words that were not tested. In experiment 2, the researchers improved the original experimental design by removing the trial-and-error element, thereby allowing them to isolate whether forgetting is truly caused by suppression rather than by confusion. Instead, they gave the participants clear, color-coded instructions indicating whether to recall the memory or suppress it by pressing the spacebar. Under these controlled conditions, the results showed that only the suppression group performed below baseline levels of forgetting, whereas the press spacebar group no longer showed significant forgetting. This demonstrates that forgetting in experiment 1 was due to accidental inhibition resulting from confusion rather than interference. Overall, the findings indicate that active inhibition plays a key role in forgetting, making memory harder to retrieve, supporting the idea that memory loss is often due to retrieval failure rather than complete loss of stored information.

As described above, the role of sleep in memory consolidation is also quite prominent. Following a study by Schapiro et al. (2018), scientists compared a sleep group to a wake group during a two-session experiment. In the study, participants learned the features of 15 novel "satellite" objects, which were artificially generated objects created specifically for the experiment. These objects belonged to three categories, and each contained both shared features common to their category and unique features tailored to each individual object, such as distinct parts and code names. After the learning process, participants completed a memory test and then underwent fMRI scanning while researchers measured patterns of hippocampal replay during these quiet moments of rest. During this, the fMRI scan was used to find and establish these neural patterns to recognize these objects later during their sleep. The sleep group then completed the second session, where participants underwent fMRI scanning again, rested in the scanner, and completed a final memory test, the next morning, while the Wake group returned later the same day. Researchers found that after the first test, the sleep group replayed more poorly remembered objects during quiet rest, allowing for a more significant memory retention of these objects in the second test. On the other hand, the wake group showed little improvement or even a decline in memory retention of these objects. This not only suggests that sleep prioritizes weaker memories but also shows that sleep plays an important role in memory consolidation. Furthermore, greater replay activity predicted better recall, especially in the sleep group. fMRI results also show increased activity in the prefrontal medial cortex after sleep, suggesting a gradual transfer of memories from the hippocampus to the cortical stage. These findings support consolidation theory and how sleep helps stabilize and strengthen newly formed memories.

Nevertheless, the involvement of the hippocampus in recall can still occur after the memory consolidation process occurs, as proposed by Bonnici et al. (2012). In their fMRI study, Bonnici et al. (2012) aimed to investigate the roles of the hippocampus and ventromedial prefrontal cortex (vmPFC) in recalling memories that occurred recently and remotely. Specifically, 12 healthy adults were asked about memories that occurred 2 weeks ago and 10 years ago, one week prior to scanning. Following this, the adults were required to recall these memories during scanning. In addition, the researchers observed that there was activity in both the hippocampus and the prefrontal cortex while recalling information; however, remote memories showed a stronger presence in the prefrontal cortex. This result goes against traditional consolidation theory since it indicates that remote memories can still depend on the hippocampus to some degree.

Additional proof for the age-related shift in memory representation comes from McWilliams et al. (2022), who performed an fMRI experiment that investigated the retrieval of autobiographical memories in relation to age. The research question in the paper is quite straightforward and clear: Are older memories stored differently in the brain in comparison to newer ones? To test this, 20 healthy participants were asked to provide personal photos from four particular moments in their lives. These photographs were taken at 1 year, 2 years, 6 years, and 14 years before the scan. The photographs were used as memory cues inside the scanner, prompting participants to mentally visit these specific events as vividly as possible. Between the memory recall of these photos, participants rested their gaze on a fixation cross, providing a baseline for comparison. Two weeks after scanning, the participants came back to complete a

recognition test and ratings of how vividly they remembered the memory. They found that older memories were consistently rated as less vivid or detailed. Participants, in fact, described them as feeling more story-like rather than immersive. The fMRI activation patterns showed that recent memories leaned more towards the hippocampus, while older memories showed a gradual shift toward cortical regions. This clearly supports the standard consolidation theory discussed above. It is worth noting that hippocampus activity may still be found in older memories, possibly proving its consistent yet decreasing role in older memories.

To put this all into perspective, these studies suggest that forgetting is often a more complex topic than the destruction of memory traces. Evidence from these case studies has indicated that memories may continue to exist even though they cannot be retrieved. The studies discussed above also provide evidence in favor of the consolidation theory and how retrieval processes may differ from short-term and long-term memories. Most studies support the idea that the hippocampus still plays a role in long-term memories.

Overall, they suggest that memory is highly dynamic and distributed, relying on interactions between hippocampal, cortical, and contextual processes. Therefore, while certain memories may weaken or become inaccessible over time, modern neuroscience increasingly supports the possibility that many forgotten memories continue to exist in some form in the brain.

DISCUSSION

This review explored the long-standing question of whether a memory can continue to exist even when it cannot be consciously recalled. This question has been continuously explored as it seems loss of memory is an irreversible situation. Throughout history, different theories of memory have emerged, from the philosophical ideas proposed by Plato and Aristotle to modern neuroscientific models that focus on the importance of neural regions such as the hippocampus and cortical networks. By examining different historical perspectives, different memory consolidation theories, and empirical findings from experimental studies, this paper implies that memories may still exist even when they are not available for conscious retrieval. However, this may only reflect a small percentage of all memory loss cases since some forms of forgetting may involve permanent biological damage or deterioration.

One of the major themes emerging from the literature is that memory is not stored in a single location or generated by a single mechanism. Instead, memory appears to rely on the interaction between multiple brain systems, specifically the hippocampus and the neocortex. After the removal of parts of his medial temporal lobe, which includes parts like the hippocampus, H.M. was unable to form new long-term memories, while the majority of his past memories were intact. This demonstrated that the hippocampus is critical for consolidating new memories, but also plays a much smaller role in long-term memories. At the same time, his intelligence and procedural skills were intact, demonstrating that different forms of memory depend on distinct neural systems, with procedural memory as a form of non-declarative memory (Squire & Wixted, 2011; see fig 1). These findings strongly support the Standard System Consolidation

Theory, which proposes that memories are initially stored in the hippocampus, but eventually consolidate over time in the neocortex (Squire et al., 2015).

Several studies reviewed in this paper provide support for this framework. For example, McWilliams et al. (2022) found that recent autobiographical memories showed stronger hippocampal activation, whereas remote memories relied more heavily on neocortical regions of the brain. It was also found that as time passes, memories rely less on the hippocampus. It is worth noting that there is still a small extent of hippocampal activity in all of the memories recalled in this experiment. This may be because enough time has not passed for it to fully depend on cortical regions for retrieval. Similarly, Schapiro et al. (2018) demonstrated that sleep enhances memory replay and strengthens consolidation, particularly for weaker memories. These findings support the idea that memories undergo a gradual process of stabilization and cortical integration over time. Together, this evidence presents memory consolidation as a consistent framework that is the standard of all different memory theories. This evidence also suggests that forgetting is not simply memory erasure but may differ based on how the memories are represented and accessed in the brain.

However, this paper also discussed various theories that question the perspective of memory consolidation. Various theories, such as Multiple Trace Theory (MTT) and Contextual Binding theory (CB), represent alternative perspectives on how memories may change over time in the brain. MTT states that whenever there is a recall process, a new trace is created for the memory, which makes the memory network stronger, and older memories become better ingrained within the neural networks. In contrast, the contextual binding theory explains that the context of the retrieval process is very significant. CB discusses the association of the memory with its context of when it was formed. From this point of view, forgetting occurs due to the disruption of the contextual cues and not memory loss (retrieval failure).

There is plenty of empirical evidence to support the claim that retrieval failure is the cause of memory forgetting. For example, Ryan and Frankland (2022) reported that mice with induced amnesia appeared incapable of naturally retrieving fear memories; yet, the researchers succeeded in their attempt to recover and retrieve those memories by stimulating the original engram cells involved in learning. From the above findings, it can be concluded that the memories can remain physically stored within the neuronal network despite the fact that the process of memory retrieval fails to take place. Likewise, the Think/no-Think experiments conducted by van Schie et al. (2023) also reinforce the idea of retrieval failure as the cause of memory loss. This experiment showed that inhibitions and suppressions could lead to memories becoming less accessible, but not necessarily erasing them. These results help demonstrate the fact that memories are frequently lost because of retrieval failure. This indicates that a forgotten memory may still exist if the memory loss was caused by retrieval failure.

Despite the evidence presented in this paper, it is important to recognize that not all memory loss comes from retrieval failure. Many factors can cause memory loss, such as storage failure or damage in specific areas of the brain (Squire & Wixted, 2011). Some forms of memory loss may also result from biological changes due to age or unhealthy habits. Neurological diseases like Alzheimer's or severe brain injuries

can permanently weaken or destroy memories (Ryan & Frankland, 2022). Therefore, not every case of memory loss is due to retrieval failure.

Going forward, a more helpful way to address whether a forgotten memory still exists is to look beyond simple “storage vs retrieval” explanations. We should examine memory based on the factors that caused the loss. Instead of framing this as a yes or no question, future research should explore the many interacting factors that affect memory loss. These include the memory's age, how many times it has been recalled, and the degree of damage in neural systems. By taking this approach, modern neuroscience can better answer this question for different situations, helping us determine whether we should strive to find a solution to restore the memory lost.

Ultimately, whether a forgotten memory can still be considered to exist depends heavily on the underlying mechanism that caused memory loss in the first place. In cases where forgetting arises from retrieval failure, such as contextual interference or suppression, the evidence reviewed highlights that memory is likely retrievable. However, in cases where forgetting stems from biological deterioration, such as neurodegenerative diseases, aging-related decline, or structural damage to memory-related areas in the brain regions, the underlying memory trace may have been destroyed and unretrievable. This distinction matters because it helps shape the causes of amnesia and what kind of treatments may be realistically useful for the improvement of these different conditions. Treatments aimed at improving retrieval may help in cases of retrieval failure, but would offer little benefit in cases where memory has decayed biologically.

Overall, the evidence throughout this paper suggests that memory is a highly dynamic, distributed, and complex phenomenon that is dependent on multiple neural systems, contextual cues, and biological conditions. Whether a forgotten memory still exists ultimately depends on the underlying mechanism responsible for forgetting: modern neuroscience continues to support the possibility of memories still existing when memory loss is caused by retrieval failure, whereas memory that has been tampered with biologically points towards a permanent loss. While it cannot be fully concluded that forgotten memory survives indefinitely, current research provides us with evidence that highlights the possibility of a memory existing even when it cannot be retrieved. Consequently, the answer to the question “Can a memory still exist even if it is forgotten?” is situation-specific, as some cases point to retrieval failure, and others to actual memory erasure.

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