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Memory – I. Processes and Constructs

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Abstract

Memory refers to the psychological processes of acquiring, retaining, storing, and later retrieving information. There are four major processes involved: encoding, preservation, storage, and retrieval. However, this is not a flawless process and errors may occur in any one or more of them. In this article, I discuss the various memory processes including theoretical constructs and working models of memory. The several identified memory types are elaborated at length. Based on existing extensive research, recommendations are made regarding memory protection, improvement, and loss palliation.

Abbreviations

AAO: American Academy of Ophthalmology; AD: Alzheimer's disease; AUD: Alcohol use disorder; COPD: Chronic obstructive pulmonary disease; CVD: Cardiovascular disease; DHHS: (U.S.) Department of Health & Human Services); FIFR: Failure, interference, forgetting; and retrieval); HSAM: Highly superior autobiographical memory; LD: Lyme disease; NDD: Neurodegenerative diseases; NEI: (U.S.) National Eye Institute; PTSD: Post-traumatic stress disorders; RER: Recency, emotion, and repetition; SNM: Semantic network model; TBI: Traumatic brain injury; TER: Time, emotion, and repetition.

Keywords

Memory emotional enhancement; Memory improvement; Memory loss palliation; Memory processes; Memory protection; Memory respiratory modulation; Memory types; Retrograde and anterograde amnesia; Vision and the brain; Working models of memory.

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Memory refers to the psychological processes of acquiring, retaining, storing, and later retrieving information. However, these processes are not flawless and errors may occur in any one or more of them. Thus, sometimes, people forget or misremember things. At other times, information is not properly encoded in

memory in the first place or improperly stored, resulting in its inaccurate retrieval. While often minor, memory problems can also be a sign of serious conditions such as Alzheimer's disease (AD), other types of dementia, and other neurodegenerative diseases (NDD). These conditions affect the quality of life and the ability to function. I will begin by presenting the different memory processes from memory creation to how memory works, to various forms of memory. This will be continued by a brief presentation on using and organizing memory. I will then discuss in some detail the several types of memory (sensory, short-term, long-term, episodic, prospective, procedural, and others). I will follow by suggesting ways gleaned from the published research literature on how to protect and effectively improve memory as well as palliating memory loss.

Memory Processes

Various processes characterize memory, but first why are memories created?

Why are memories created?

We all have a strong intuitive sense of what the different types of memory are. One of the fundamental roles of memory is to make our behavior appropriate for our current situation and, based on past experiences, to allow us to rapidly change and adapt our behavior when our environment changes. Memories serve many purposes, from allowing us to revisit and learn from past experiences to storing knowledge about the world and how things work. Memory helps us survive! However, when memory becomes dysfunctional, resulting in memories that are too strong or in memory loss, problematic changes in our behavior and our emotions devolve and potentially contribute to a variety of mental health disorders including addiction, anxiety, dementias, post-traumatic stress disorders (PTSD), etc. Memory contributes to mental health states and, conversely, both mental and physical states can dramatically impact it, what memories we store, and what memories we recall at any given time.

The creation of a memory is a conversion process

The creation of memory is a conversion process in which a select amount of perceived information is converted into a more permanent form. A subset of that memory will be secured in long-term storage, accessible for future use. Many factors during and after the creation of a memory influence what (and how much) gets preserved.

Researchers have long believed that memories form due to changes in the corpus (the soma) of the brain neurons. Our understanding today is rather that memories are created through the connections (the synapses) that exist between these neurons—either by strengthening these connections or through the growth of new connections. Changes in the synapses are associated with the learning and retention of new information. Strengthening these connections helps commit information to memory. This is why reviewing and rehearsing information improves the ability to remember it. Practice strengthens the connections between the synapses that store that memory.

How memory works? A theoretical construct

Memory is a continually unfolding process. Initial details of an experience take shape in memory; the brain's representation of that information then changes over time. With subsequent reactivations, the memory grows stronger or fainter and takes on different characteristics. Memories reflect real-world experience, but with varying levels of fidelity to that original experience. The degree to which the memories formed is accurate or easily recalled depends on a variety of factors, from the psychological conditions in which information is first translated into memory to the manner in which we seek—or are unwittingly prompted—to conjure details from the past. The working process of the memory is encapsulated by the following theoretical model. (It is important to note that this is only a theoretical model

devised to help understand how memory works, and not a true description of reality.)

- **Encoding:** This is the first stage. It is the process by which the details of a person's experience are converted into a form that can be stored in the brain. People are more likely to encode details of what they are paying attention to and details that are personally significant.

- **Retention and consolidation:** While memories are usually described in terms of mental concepts, such as single packages of personal experience or specific facts, they are ultimately reducible to the workings and characteristics of the ever-firing cells of the brain. Scientists have narrowed down regions of the brain that are key to memory and developed an increasingly detailed understanding of the material form of these mental phenomena. The hippocampus and other parts of the medial temporal lobe are critical for many forms of memory. However, various other parts of the brain play roles as well, including: the more recently evolved cerebral cortex (the outermost layer of the brain); the deep-seated structures such as the basal ganglia; and the amygdala (see Figure 1). Other processes are also important for memory as well, including the integration of emotional responses into memory. The extent to which different brain regions are involved in memory depends on the type of memory.

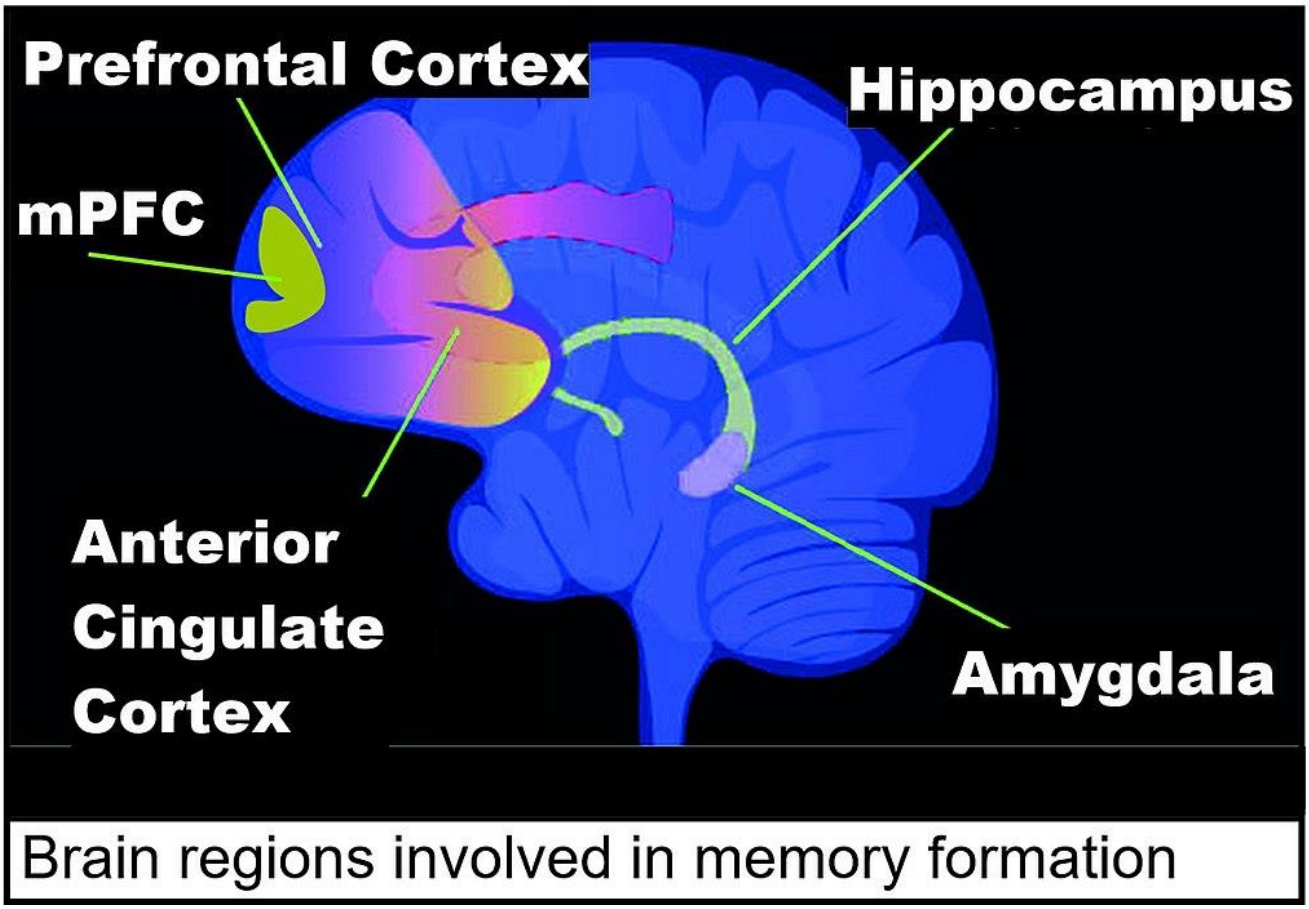

Figure 1: Brain regions involved in memory formation

- **Storage:** Memory involves changes to the brain's neural networks. Neurons in the brain are connected by synapses, which are bound together by chemical messengers (the neurotransmitters) to form larger networks. Memory storage is thought to involve changes in the strength of these connections in the areas of the brain that have been linked to memory.

- **Retrieval:** Much of our stored memory lies outside of our awareness most of the time, except when we actually need to use it. The memory retrieval process allows us to bring stored memories into conscious awareness. After memories are stored in the brain, they must be retrieved in order to be useful. While we may or may not be consciously aware that information is being summoned from storage at any given moment, this stage of memory is constantly unfolding—and the very act of remembering changes how memories are subsequently filed away. Retrieval follows the stages of encoding and storage. It is the stage in which the information saved in memory is recalled, whether consciously or unconsciously. Retrieval includes both 'intentional remembering' (as when one thinks back to a previous experience or tries to put a name to a face) and more 'passive recall' (as when the meanings of well-known words or the notes of a song come effortlessly to mind). There are retrieval cues in the above process (different types of stimulus that initiate remembering). Cues can be external (such as an image, a text, a scent, or some other stimulus that relates to the memory) or internal (such as a thought or sensation that is relevant to the memory). They can be encountered inadvertently or deliberately sought in the process of deliberately trying to remember something.

"Figure 2 gives a detailed overview of the term "memory" as used in various branches of academia"

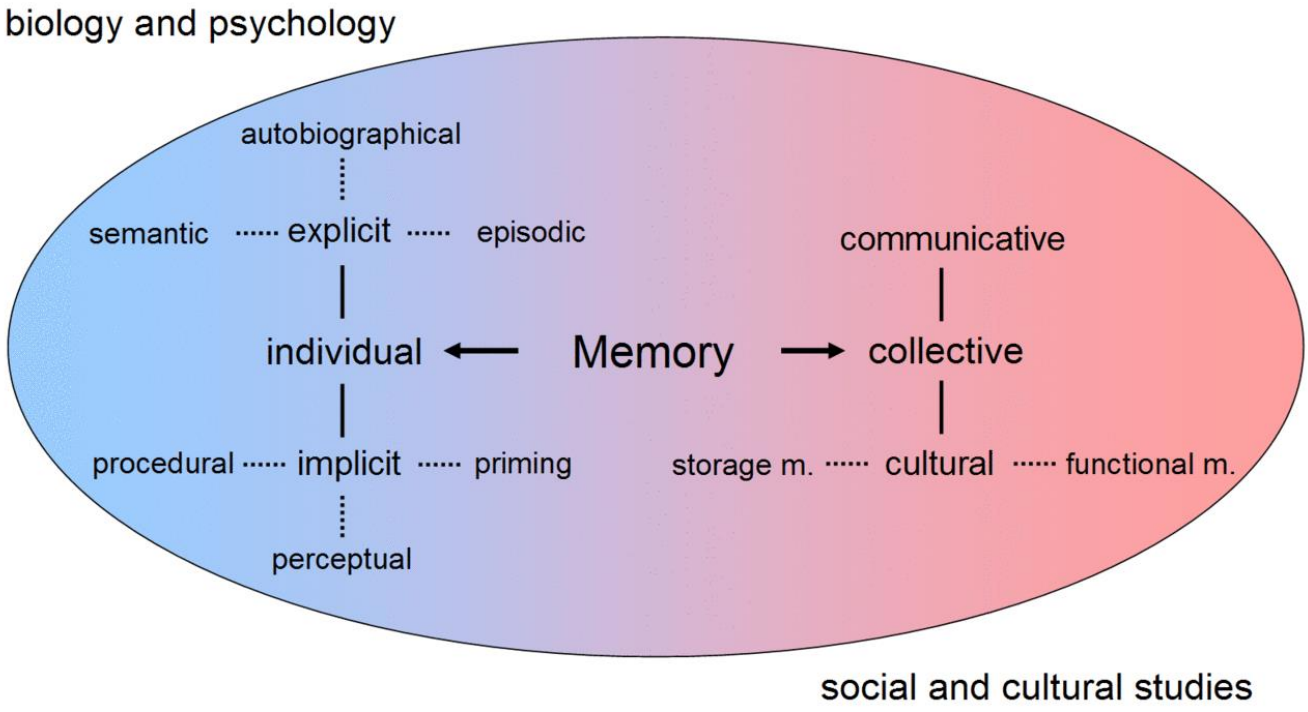

Figure 2: Overview of the forms and functions of memory

"Figure 3 is a working model of memory, showing the mutual relationships between the central executive, the phonological loop, and the visuo-spatial sketchpad"

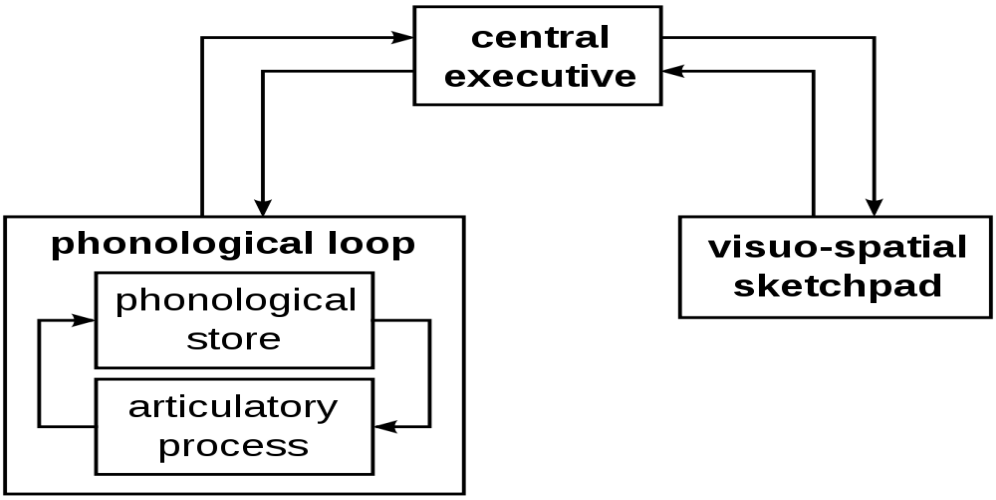

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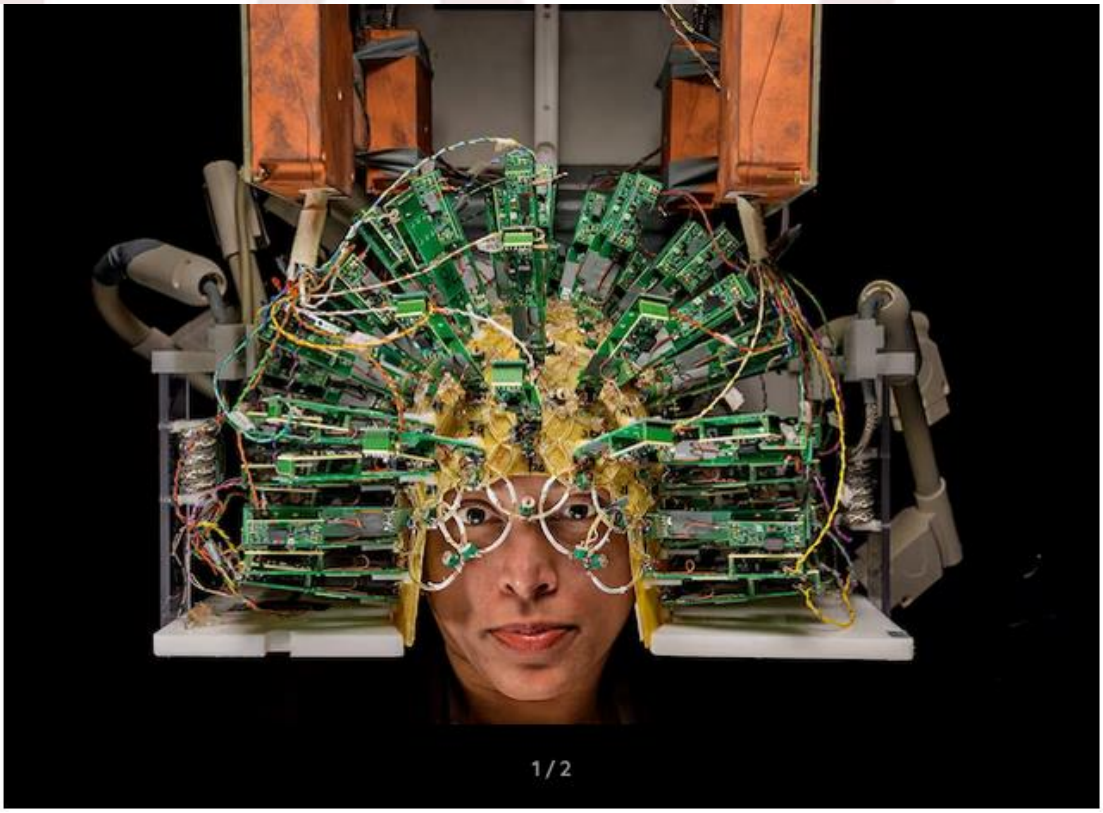
Figure 3: Working model of memory

Scanners are employed to study the brain and its processes as illustrated in Figure 4, which shows an engineer wearing a helmet of sensors, part of a brain scanner, at the Martinos Center for Biomedical Imaging, Massachusetts General Hospital.



Photograph by Robert Clark

Figure 4: The Massachusetts General Hospital's brain scanner

What do we remember?

Most people do not remember everything, so how do their brains sort out what information to remember and what not to remember? Time, emotion, and repetition (acronym: **TER**) all seem to contribute to whether information or an event is remembered. The basic rule is that events and information with significance are remembered. In particular, remembering recent events is likely to be more relevant for functioning than most things from long ago. But, why is this selectivity in memory important? Why not just remember everything? Is it simply a question of capacity (not enough synapses in the brain to store all the information from every day)? We do not know. Even if we do have the storage capacity, storing all memories is inefficient.

If the purpose of memory is to guide behavior and allow survival, then, a lot of every day experience will be largely irrelevant to the ability to function in the future. But, some events will be critical for survival. Recency, emotion, and repetition (acronym: **RER**), all indicate how important this information is likely to be in the current environment. So emotion contributes to not only the content of the memory but also whether something is remembered at all.

Individuals with "highly superior autobiographical memory" (HSAM) – see below - remember almost everything about events from their lives—yet they lead normal lives, exhibit normal IQ, and are indistinguishable from others across a range of other cognitive functions. Why? This may be because HSAM individuals do not show the same kinds of extreme memory for all kinds of memory (autobiographical, semantic, unconscious, associative conditioning, etc.). It may also be that HSAM individuals are less likely to have interference between these different types of memories.

What if the brain gets it wrong? Of course, if the brain *can* do something, it can also go wrong, and this is no exception: How the brain codes for "important" information can be hacked or disrupted by one's own experiences. For example, drugs are widely thought to hijack the brain's system for pleasure and reward, cause stronger memories for people, places, and things associated with them, which in turn contributes to drug-taking and relapse to drug-taking in addiction. And strong emotions during trauma contribute to strong, long-lasting, and intrusive memories that are one component of PTSD.

Memory strength

Modality is important in determining the strength of the memory. For instance, auditory creates stronger memory abilities than visual. This is shown by the higher recency and primacy effects of an auditory recall test compared to that of a visual test. Research has shown that auditory training can help preserve memory abilities as one ages and increases the life span on cognition abilities in one's advanced years.

False and distorted memories

The memory system has been built to craft a useful account of past experiences, not a perfect one. Memories have to be reconstructed in order to be used, and the piecing-together of details may at times be inaccurate or even false, contaminating the record. Memories may be distorted or rendered less accurate based on conditions when they were first formed, such as how much attention was paid during the experience. False memories can be simple (such as erroneously concluding having been shown a word that actually was not) or believing having experienced a dramatic event that did not take place. People may produce such false recollections by unwittingly drawing on the details of actual, related experiences, or in some cases, as a response to another person's detailed suggestions (perhaps involving some true details) about an imaginary event that is purported to be real.

The malleability of memories over time means internal and external factors can introduce errors. These may include a person's knowledge and expectations about the world (used to fill in the blanks of a memory) and misleading suggestions by other people about what occurred.

How long do memories last?

Some memories are very brief, just seconds long, and allow people to take in sensory information about the world. Short-term memories are a bit longer and last about 20 to 30 seconds. These memories mostly consist of the information people are currently focusing on and thinking about. Some memories are capable of enduring much longer—lasting days, weeks, months, or even decades. Most of these long-term memories lie outside of one's immediate awareness but can be drawn into consciousness when needed.

Why do we remember painful memories?

Many times, painful memories tend to hang on for long periods of time? Research suggests that this is because of increased biological arousal during the negative experience, which increases the longevity of that memory.

Memory failure

Forgetting is a surprisingly common event. There are four basic underlying explanations (acronym" **FIFR**):

- Failure to store a memory;
- Interference;
- Motivated forgetting; and
- Retrieval failure.

Research has shown that one of the critical factors that influence memory failure is time. Information is often quickly forgotten, particularly if not actively reviewed and rehearsed. It can be simply lost from memory or it was never stored correctly in the first place. Further, some memories compete with one another, making it difficult to remember certain information. In other instances, people actively try to forget things that they simply do not want to remember.

How we remember things

To understand how we remember things, it is incredibly helpful to study how we forget them - which is why neuroscientists study amnesia (the loss of memories or the ability to learn).

The two main types of amnesia

Amnesia is usually the result of some kind of trauma to the brain, such as a head injury, a stroke, a brain tumor, or chronic alcoholism. There are two main types of amnesia:

- Retrograde amnesia: It occurs when things known before the brain trauma are forgotten after it.
- Anterograde amnesia: It occurs when brain trauma curtails or stops someone's ability to form new memories.

It seems that short-term and long-term memories do not form in exactly the same way, nor do declarative and procedural memories. There is no one place within the brain that holds all of the memories. Different areas of the brain form and store different kinds of memories, and different processes may be at play for each. For instance, emotional responses such as fear reside in the amygdala; memories of skills learned are associated with the striatum. The hippocampus is crucial for forming, retaining, and recalling declarative memories. The

temporal lobes play a crucial role in forming and recalling memories.

Using Memory

To use the information that has been encoded into memory, it first has to be retrieved. There are many factors that can influence this process, including the type of information being used and the retrieval cues that are present. An example of a perplexing memory retrieval issue is known as 'ethological' or the 'tip-of-the-tongue' phenomenon.

Organizing Memory

The ability to access and retrieve information from long-term memory allows us to actually use these memories to make decisions, interact with others, and solve problems. But, in order to be retrievable, memories have to be organized in some way. When areas of the brain connected to memory are damaged, the ability to identify persons, events is impaired.

One way of thinking about memory organization is the 'semantic network model (SNM)'. This model suggests that certain triggers activate associated memories, for example, seeing or remembering a specific place might activate memories that have occurred in that location.

Certain stimuli can also sometimes act as powerful triggers that draw memories into conscious awareness. Scent is one example, which can help trigger autobiographical memories in people who have Alzheimer's disease (AD), underscoring just how powerful memories can be.

Types of Memory

A person's memory is a sea of images and other sensory impressions, facts and meanings, echoes of past feelings, and ingrained codes for how to behave—a diverse well of information. Naturally, there are many ways (some experts suggest there are hundreds) to describe the varieties of what people remember and how. While the different brands of memory are not always described in exactly the same way by memory researchers, some key concepts have emerged.

These forms of memory, which can overlap in daily life, have also been arranged into broad categories. Memory that lingers for a moment (or even less than a second) could be described as short-term memory, whilst any kind of information that is preserved for remembering at a later point can be called long-term memory. Memory experts have also distinguished explicit memory, in which information is consciously recalled, from implicit memory, the use of saved information without conscious awareness that it is being recalled.

The flow chart diagram of Figure 5 is a representation of the multi-store model of memory. It shows the transformation process from sensory to short-term memory through attention, to long-term memory through transfer and retrieval, and rehearsal within short-term memory.

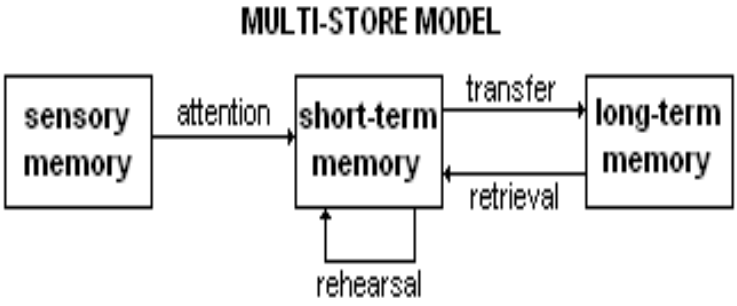


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Figure 5: The multi-store model of the memory processes

Memory in Freudian psychology

Characteristic details of these various types of memory are briefly and their main features are described in Table 1 from a Freudian psychology viewpoint.

Type	In Freudian psychology	Features
Autobiographical	Broad category of memories related to a person's own life	Earliest memories (from childhood) to adult ones
Emotional	Powerful force for sealing memories	Emotional memory enhancement that may have evolved in part because it helps to preserve useful information for future behavior.
Sensory	The short-term memories of just-experienced sensory stimuli	o Visual-spatial (or iconic) o Auditory (or echoic) o Olfactory o Haptic
Short-term (or **active** or **working) memory**	The conscious mind (explicit memory)	o Generated from sensory memories o Kept ~ 20-30 sec o Can be stretched using memory strategies
Long-term (or **semantic**)	Preconscious and unconscious mind (implicit memory)	o Can be recalled into short-term memory
Episodic (related: **autobiographical**)		o Can be very recent or very old
Prospective		o Forward thinking recalling from the past
Procedural (includes **kinesthetic** for physical behaviors)		o How to do things (physical, mental)

Table 1: Certain types of memory in Freudian psychology

The various types of memory

So far, 22 types and 5 subtypes of memory have been identified so far. For convenience, these are listed below in alphabetical order:

- **Associative learning:** Another type of episodic memory (see below).

- **Autobiographical:** Autobiographical memory is a broad category of conscious memories about one's own experiences. It encompasses facts and other non-episodic forms of information related to a person's own life. This complex body of information can range from basic details about one's past to vivid impressions of significant personal experiences. Together, they form a person's internal life story. It is important because it allows for the development and refinement of a sense of self, including who one is, how one has changed, and what one might be like in the future. It allows a person to identify connections between personally relevant events across time (and between those events and one's sense of self), but also significant changes—all of which can be sources of meaning. The life stories people develop based on autobiographical memory also become a way to communicate who they are to others.

- **Declarative (see explicit):** The acquisition or encoding, storage and consolidation, and retrieval of representations of facts and events. It provides the critical substrate for relational representations, i.e., for spatial, temporal, and other contextual relations among items, contributing to representations of events (episodic memory) and the integration and organization of factual knowledge (semantic memory). These representations facilitate the inferential and flexible extraction of new information from these relationships.

- **Emotional and nostalgia:** Emotion is a powerful force for sealing experiences into memory, and some of the most important parts of our life stories are memories of emotionally-intense experiences (e.g., moments of ecstasy, awe, or tranquility). Numerous studies have shown that the most vivid autobiographical memories tend to be of emotional events, which are likely to be recalled more often and with more clarity and detail than neutral events. The activity of emotionally-enhanced memory retention can be linked to human evolution; during early development, responsive behavior to environmental events would have progressed as a process of trial and error. Artificially inducing this instinct through traumatic physical or emotional stimuli essentially creates the same physiological condition that heightens memory retention by exciting neuro-chemical activity affecting areas of the brain responsible for encoding and recalling memory. This memory-enhancing effect of emotion has been demonstrated in many laboratory studies, using stimuli ranging from words to pictures to narrated slide shows, as well as autobiographical memory studies. However, emotion does not always enhance memory. Nostalgia is a longing for the past, an experience often described as bittersweet. The "emotional enhancement" of memory may have evolved in part because it helps to preserve information that is useful for future behavior.

- **Episodic:** It captures the "what, where", and "when" of daily lives. It refers to the recall of a particular event (or "episode") experienced in the past. The experiences conjured by episodic memory can be very recent or decades-old. A related concept is autobiographical memory, (see above), which is the memory of information that forms part of a person's life story. However, while autobiographical memory includes memories of events in one's life, it can also encompass facts and other non-episodic forms of information.

- **Explicit:** Consists of the sorts of memories experienced consciously. Some are facts or "common knowledge", others consist of past events experienced. (See declarative memory.)

- **Implicit:** Unconscious build-up of memories (includes procedural memory).

- **Intrusive:** Sensory memories of a traumatic event(s) that spring to mind involuntarily, and can evoke strong emotions and disrupt functioning in daily life. They are their debilitating core features and are triggered by certain clinical symptoms (PTSD, anxiety, depression, and insomnia).

- **Kinesthetic (see implicit):** Refers specifically to memory for physical behaviors. (See procedural memory.)

- **Long-term (or semantic):** The memory which refers to the continuing storage of information; the ability to recall concepts and general facts that are not related to specific experiences. It is composed of pieces of information such as facts,

meanings, concepts, and definitions. The details that make up semantic memory can correspond to other forms of memory. In Freudian psychology, this memory would be called the preconscious and unconscious mind. This information is largely outside of our awareness, but can be called into working memory to be used when needed. Some memories are fairly easy to recall, while others are much more difficult to access. While most people do not remember much from their first years of childhood, the memories that remain can be vivid and personally meaningful. These earliest long-term memories, which often date back to the preschool years, help make up the beginning of the individual's autobiographical memory. Yet, well before these lasting memories are formed, babies' brains retain information learned from the world around them. The youngest age one can remember is the fourth year of life (specifically ages 3 to 3-and-a-half) although people tend to misdate these memories and believe they may actually be formed somewhat earlier. There is also variation in the age of these early memories between individuals:

- **Motor:** Required by motor skills without which behavior is only reflexes and stereotypes.

- **Non-declarative (see implicit memory):** Can shape the body's unthinking responses.

- **Objective:** The objective recollection of places, events, dates, people, persons. (See also subjective memory.)

- **Photographic memory:** The memory of things seen only once (photographs, objects, written documents, etc.).

- **Procedural (see implicit):** The long-term memory of how to do things (both physical and mental) such as, for example, how to tell time by reading the numbers on a clock) typically stays the same (both physical and mental). It is involved in the process of learning skills (from the basic ones people take for granted to those that require considerable practice). A related term is kinesthetic memory, which refers specifically to memory for physical behaviors.

- **Prospective memory:** The forward-thinking memory - recalling an intention from the past in order to do something in the future. It is essential for daily functioning in that memories of previous intentions, including very recent ones, ensure that people execute their plans and meet their obligations when the intended behaviors cannot be carried out right away, or have to be carried out routinely.

- **Semantic:** The ability to recall concepts and general facts that are not related to specific experiences. For example, understanding the concept that clocks are used to tell time. This type of memory also includes vocabulary and knowledge of language. (See long-term memory.)

- **Sensory:** Sensory memories are what psychologists call "the short-term memories of just-experienced sensory stimuli such as sights and sounds". Sensory memories are the earliest stages of memory. During these stages, sensory information from the environment is stored for a very brief period of time, generally for no longer than a half-second for visual information and three or four seconds for auditory information. Attending to sensory memory allows some of this information to pass into the next stage: short-term memory. Sense-related memories, of course, can also be preserved long-term. Sensory memories

corresponding to the various sensory triggers include:

◦ **Verbal:** Used in cognitive psychology, it refers to memory of words and other abstractions involving language.
◦ **Visual-spatial (or iconic) memory:** It refers to memory of how objects are organized in space; it lasts for less than a half-second.
◦ **Auditory (or echoic) memory** is the brief memory of something just heard. It can last for 3-4 seconds.
◦ **Olfactory memory:** The memory of stored sensory impressions of smells.
◦ **Haptic memory:** The memory for stored sensory impressions of skin sensations.

- **Short-term (also known as active memory):** The storage of information for a brief amount of time. It is generated from sensory memories. To be distinguished from working memory (see below). It refers to the processes that are used to temporarily store, organize, and manipulate information. It corresponds to the information we are currently aware of or thinking about. The terms short-term memory and working memory are sometimes used interchangeably, and both refer to storage of information for a brief amount of time. However, working memory can be distinguished from general short-term memory in that working memory specifically involves the temporary storage of information that is being mentally manipulated and held in mind so that it can be used in the moment. In Freudian psychology, this memory would be referred to as the conscious mind. As indicated previously, information in short-term memory is generated from sensory memories. While many short-term memories are quickly forgotten, attending to this information allows it to continue to the next stage: long-term memory. Most of the information stored in active memory will be kept for approximately 20 to 30 seconds. This capacity can be stretched somewhat by using memory strategies such as 'chunking', which involves grouping-related information into smaller chunks. Additional forms of short-term sensory memory are thought to exist.

- **Spatial:** In cognitive psychology and neuroscience, it is a form of memory responsible for the recording and recovery of information needed to plan a course to a location and to recall the location of an object or the occurrence of an event. It is necessary for orientation in space. It can also be divided into:

1. **Egocentric** and
2. **Allocentric.**

Spatial memory has representations within working, short-term memory, and long-term memory. Research indicates that there are specific areas of the brain associated with spatial memory. Many methods are used for measuring spatial memory in children and adults.

- **Subjective:** The subjective recollection of places, events, dates, people, persons. (See also objective memory.)

- **Working:** The active maintenance and flexible updating of goal/task relevant information (items, goals, strategies, etc.) in a form that has limited capacity and resists interference. It involves the manipulation of information that is being obtained and, then, using this information to complete a task. Working memory can be distinguished from general short-term memory in that it specifically involves the temporary storage of information that is being mentally manipulated and held in mind so that it can be used in the moment. In Freudian psychology, this memory would be referred to as the conscious mind.

How to protect memory?

While AD and other age-related memory problems affect many older adults, the loss of memory during later adulthood might not be inevitable. While certain abilities do tend to decline with age, researchers have found that individuals in their 70s often perform just as well on many cognitive tests as those in their 20s. By the time people reach their 80s, it is common to experience some decline in cognitive function. But some types of memory even increase with age.

The following lifestyle strategies may help protect the brain of the aging person:

- **Avoiding stress:** Stress can have detrimental effects on areas of the brain associated with memory, including the hippocampus.
- **Avoiding drugs, alcohol, and other neurotoxins:** Drug use and excessive alcohol consumption have been linked to the deterioration of synapses (the connections between neurons). Exposure to dangerous chemicals such as heavy metals and pesticides can also have detrimental effects on the brain.
- **Getting enough exercise:** Regular physical activity helps improve oxygenation of the brain, which is vital for synaptic formation and growth.
- **Stimulating the brain:** People who have more mentally stimulating jobs are less likely to develop dementia.
- **Maintaining a sense of self-efficacy:** Self-efficacy refers to the sense of control that people have over their own lives and destiny. Having a strong sense of self-efficacy has been associated with maintaining good memory abilities during old age and has also been linked to lowered stress levels.

How to improve memory effectively?

Human memory is a complex process that researchers are still trying to better understand. Our memories make us who we are, yet the process is not perfect. While we are capable of remembering an astonishing amount of information, we are also susceptible to memory-related mistakes and errors. Fortunately, there are plenty of things that can be done to increase memory power. While simply revisiting a newly learned fact, the definition of a word, or some other information can help reinforce someone's memory for it and additional tools and processes can help make the effort to retain those details more powerful. The following 15 research-proven strategies can effectively improve memory, enhance recall, and increase retention of information. As few or as many such strategies are differently needed by different people.

1. Focusing attention

Attention is one of the major components of memory. Actively attending to it (such as, away from distractions and diversions, setting aside a short period of time to be alone, getting some space to focus on one's work, etc.) is needed for information to move from short-term memory into long-term memory.

2. Avoiding cramming

"Cramming"—studying in one long, continuous period—can be an unhelpful study habit. Studying materials over a number of sessions gives the time needed to adequately process information.

3. Structuring and organizing

Researchers have found that information is organized in memory in related clusters. To help group related concepts, one can structure and organize materials, group similar concepts and terms together, or make an outline of notes and textbook readings.

4. Utilizing mnemonic devices

Mnemonic devices are ways of enhancing memory that can involve elaboration—connecting what one is trying to remember to other information in memory—organizing to-be-remembered details more efficiently in memory, and making use of mental visualization. Examples of mnemonics include: Forming a series of words into an acronym; grouping to-be-remembered items together into categories; creating a 'memory palace' by visualizing a series of objects, events, or other things appearing in a familiar physical space.

5. Chunking the information

'Chunking' is the combination of to-be-remembered pieces of information, such as numbers or letters, into a smaller number of units (or “chunks”), making them easier to remember. A simple example is the reduction of a phone number into three parts (which one might repeat to oneself in three bursts), though more complex forms of chunking are thought to help account for experts’ superior memory for certain kinds of information (such as chess positions).

6. Elaborating and rehearsing

In order to recall information, one needs to encode it into long-term memory. One of the most effective encoding techniques is known as 'elaborative rehearsal'.

7. Testing memory of learned material

Testing memory of learned material, such as a passage of text, can enhance memory for that material - above and beyond re-reading it. Self-testing can help with learning, whether responding to self-generated questions or flashcards related to that information or questions provided by others. Explaining a newly learned concept to oneself or someone else may also help reinforce memory for it.

8. Visualizing concepts

Many people benefit greatly from visualizing information (for example, photographs, charts, and other graphics). Personal cues (such as charts, figures, notes on margins, color highlighting, making flashcards of various terms etc.) can be created if visual ones are not available.

9. Relating new information to things already known

When studying unfamiliar material, relate this information to what is already known. By establishing relationships between new ideas and previously existing memories, one can dramatically increase the likelihood of recalling the recently learned information.

10. Reading out-loud

Reading materials out loud significantly improves memory of the material. Teaching new concepts to others enhances understanding and recall.

11. Paying closer attention to details

Paying closer attention to details in the moment can make it easier to remember them later. People can learn to focus better. Mindfulness techniques may help. Minimizing distractions and avoiding multitasking while learning information could also help with remembering.

12. Paying extra attention to difficult information

The order of information can play a role in recall (this is known as 'serial position effect'). The beginning and the ending of a text may be easier to recall. While recalling middle information can be difficult, it can be overcome by spending extra time rehearsing this information. Another strategy is to try restructuring it.

13. Varying the study routine

Another way to increase information recall is to occasionally change the study routine. By adding an element of novelty to the study sessions such as change of place or/and time, spacing apart the time spent studying, rather than massing it together, etc.) one can increase the effectiveness of efforts and significantly improve long-term recall.

14. Securing enough sleep

Sleep is important for memory and learning. It has been linked to memory loss. It is thought to play an important role in the consolidation of memories. So has restless sleep and sleep that gets disturbed often. Getting enough healthy sleep is a priority. Taking a nap after learning something new can actually help learn faster and remember better. Sleeping after learning something new actually leads to physical changes in the brain. Mice experiments have shown that sleep-deprived mice experienced less dendritic growth following a learning task than well-rested mice.

Procedural memories (memory for physical skills, for example) as well as memories for experiences and for new knowledge, seem to benefit from sleep. Consequently, failing to prioritize sleep (or struggling with sleep for other reasons) is detrimental to optimal memory consolidation.

15. Maintaining healthy behaviour

In addition to the above strategies, striving to live a healthy and active lifestyle can help enhance short term memory and preserve memory ability over time. Fortunately, there are plenty of things that can be done to increase memory power. While simply revisiting a newly learned fact, the definition of a word, or some other information can help reinforce someone's memory for it and additional tools and processes can help make the effort to retain those details more powerful. The following 15 research-proven strategies can effectively improve memory, enhance recall, and increase retention of information. As few or as many such strategies are differently needed by different people.brain back to the heart. It is a rare disorder, which can present under two forms. The cause of the most common form ("septic") is usually from a spreading infection in the nose, sinuses, ears, or teeth (Staphylococcus aureus and Streptococcus are often the associated bacteria). CST symptoms include: Decrease or loss of vision, chemosis, exophthalmos (bulging eyes), headaches, and paralysis of the cranial nerves. This infection is life-threatening and requires immediate treatment, which usually includes antibiotics and sometimes surgical drainage.

Why we forget?

Forgetting can be frustrating but much of what people forget escapes memory quietly. Experts say "it is a feature, not a bug, of the way memory works". Forgetting may actually be helpful for remembering in the sense that the forgotten less-useful details will not interfere with the retrieval of useful ones. And forgetting unpleasant or painful memories can make one feel better about past experiences and reduce the burden of negative ones.

What conditions can cause memory loss?

Information may be forgotten because one was not paying close enough attention initially or has not reinforced the memory of the information by retrieving it. A more recently acquired memory may interfere with the retrieval of an earlier one. Several health-related conditions can cause memory loss, some of which such as stress, lack of sleep, and certain behaviors (e.g., excessive alcohol consumption) can also temporarily impair memory (causing a "blackout," in the case of drinking). Often, these causes may occur individually or together and usually resolve after treatment. These include:

- **Aging:** Aging can change the structures and chemistry of the brain, affecting a person's ability to learn new information and retrieve previously known information. The symptoms of age-related memory loss are usually mild and temporary.

- **Alcohol use disorder (AUD):** Heavy alcohol consumption or alcohol use disorder (AUD) can lead to the loss of brain cells (neurons) and cause cognitive decline.

- **Alzheimer's disease (AD):** Memory loss is one of the most common symptoms of AD. A person with this condition may have difficulty remembering important information and completing daily tasks.

- **Depression:** People with one or more symptoms of depression can have memory complaints. Some antidepressants can cause memory loss.

- **Head trauma:** Moderate to severe traumatic brain injury (TBI) from sports or accidents can affect the retention of short- and long-term memory.

- **Medications:** Certain medications can interfere with the brain's chemistry and lead to short- and long-term memory loss. However, this often resolves with medication changes. Examples of medications that may cause memory loss include psychoactive and nonpsychoactive drugs, antidepressants, anticonvulsants, and others. Older adults are also more likely to develop drug-induced cognitive impairment than young adults. This may be due to drug toxicity from impaired liver and kidney functions.

- **Sleep deprivation:** People who lack quality sleep can have memory issues, which can directly affect their daytime activities.

- **Stress:** Stress affects memory in a time-dependent fashion. It can affect the formation of short- and long-term memory, the type of memories a person forms, and the ability to recall vital information.

- **Vitamin B-12 deficiency:** People with a vitamin B-12 deficiency have a greater likelihood of memory loss and other cognitive issues. This may be due to poor myelination − a condition that damages the myelin sheath that covers the nerve fibers in the brain.

- **Other causes:** People with certain conditions, such as COVID-19, herpes, HIV, gum disease, Lyme disease (LD), syphilis, urinary tract infection, and lung infections, may have a higher risk of neurological complications, including memory loss. Other causes may include diabetes, chronic obstructive pulmonary disease (COPD), renal dysfunction, endocrine disorders, cardiovascular diseases (CVD), and other neurodegenerative conditions. In many instances, treating the underlying infection can resolve the memory loss.

How to palliate memory loss?

For most people, it would be hard to imagine a life in which the mind did not routinely discard once-remembered details. A normal degree of forgetting is a core element of memory, allowing people to dispense with information for which they no longer have much use. Of course, forgetting causes problems, too. Minor failures to remember can be inconvenient at any age, and they may become more frequent and troublesome later in life. As indicated above, declines in certain types of memory ability are a typical part of aging and do not

necessarily reflect the development of a medical condition such as AD. Although there are no guarantees when it comes to preventing memory loss or dementia, some activities might help. Experts have proposed a variety of tactics for staving off memory decline and managing typical levels of memory loss, including the following simple ways to sharpen memory advocated by the Mayo Clinic:

1. Being physically active every day

Physical activity raises blood flow to the whole body, including the brain. This might help keep memory sharp. For most healthy adults, the (U.S.) Department of Health & Human Services (DHHS) recommends "at least 150 minutes a week of moderate aerobic activity, such as brisk walking, or 75 minutes a week of vigorous aerobic activity, such as jogging". It is best if this activity is spread throughout the week".

2. Staying mentally active

Just as physical activity keeps the body in shape, mind activities (for example, reading, solving cross-word puzzles, playing games, learning to play a musical instrument, trying a new hobby, volunteering at a local school or with a community group.etc.) help keep the brain in shape and prevent some memory loss.

3. Spending time with others

Social interaction helps ward off depression and stress can contribute to memory loss, especially if living alone.

4. Staying organized

Staying organized can be accomplished by some or all of the following measures: uncluttering one's own environment; keeping track of tasks, appointments, and other events in a notebook, calendar or electronic planner; repeating each entry out-loud as it is being written down; keeping to-do lists up to date; checking off finished items; keeping one's wallet, keys, glasses, and other essential items in a set place in the home so they are easy to find.

5. Eating a healthy diet

A healthy diet is good for the brain. It includes: Eating fruits, vegetables, and whole grains; choosing low-fat protein sources, such as fish, beans and skinless poultry; not abusing alcohol that can lead to confusion and memory loss.

6. Managing chronic health problems

These chronic conditions include: High blood pressure, diabetes, obesity, depression, and hearing loss. The better one takes care of oneself, the better memory is likely to be. Medicines taken should be regularly reviewed as some can affect memory.

Several sidebars are provided below. Sidebar 1 discusses how emotional significance enhances memories. Sidebar 2 shows how respiration modulates cognitive function and memory. Sidebar 3 explores the relationship between vision and the brain. Sidebar 4 likewise explores the relationship between memory and mental health.

Conclusions and take-aways

- Memory refers to the psychological processes of acquiring, retaining, storing, and later retrieving information. There are four major processes involved: encoding, preservation, storage, and retrieval. However, this is not a flawless process.

- Memories are created to help ensure that our behavior fits the present situation and we can adjust them based on experience. They serve many purposes, from allowing us to revisit and learn from past experiences to storing knowledge about the world and how things

work.

- When memory becomes dysfunctional, resulting in memories that are too strong or in memory loss, problematic changes in our behavior and our emotions devolve and potentially contribute to a variety of mental health disorders.

- The creation of memory is a transformation process in which a select amount of perceived information is converted into a more permanent form. A subset of that memory will be secured in long-term storage, accessible for future use. Many factors during and after the creation of a memory influence what (and how much) gets preserved.

- Memories are created through the connections that exist between neurons−either by strengthening these connections or through the growth of new connections. Changes in the connections between nerve cells (known as synapses) are associated with the learning and retention of new information. Strengthening these connections helps commit information to memory.

- Memory is a continually unfolding process, reflecting real-world experience with varying levels of fidelity and accuracy. The working process includes: Encoding, retention and consolidation, storage, and retrieval.

- The memory system has been built to craft a useful account of past experiences, not a perfect one. Memories may be distorted or rendered less accurate based on conditions when they were first formed. False memories can be simple or complex. The malleability of memories over time means internal and external factors can introduce errors.

- Memories last for different times, some are very brief lasting just seconds. Short-term memories last about 20-30 seconds. Others are capable of enduring much longer, lasting days, weeks, months, or even decades. Most of these long-term memories lie outside of immediate awareness but can be drawn into consciousness when needed. Many times, painful memories tend to hang on for long periods of time.

- To use the information that has been encoded into memory, it first has to be retrieved. Many factors that can influence this process, including the type of information being used and the retrieval cues that are present.

- The ability to access and retrieve information from long-term memory allows us to actually use these memories to make decisions, interact with others, and solve problems. But, in order to be retrievable, memories have to be organized in some way. One way of thinking about memory organization is the 'semantic network model'.

- Certain stimuli can sometimes act as powerful triggers that draw memories into conscious awareness.

- A person’s memory is a sea of images and other sensory impressions, facts and meanings, echoes of past feelings, and ingrained codes for how to behave−a diverse well of information. These forms of memory, which can overlap in daily life, have been arranged into broad categories: Sensory memories corresponding to the various sensory triggers (visual-spatial or iconic), auditory (or echoic), short-term memory (or active, working, or the conscious mind), long-term memory (or pre-conscious and unconscious mind). Memory experts have

also distinguished explicit and implicit memory. Characteristic details of these various types of memory have been described.

- While Alzheimer's disease, other neurodegenerative disorders, and other age-related memory problems affect many older adults, the loss of memory during later adulthood might not be inevitable. It is common to experience some decline in cognitive function, but some types of memory even increase with age. Simple lifestyle strategies have been suggested to help protect the brain of the aging person.

- Human memory is a complex process that researchers are still trying to better understand. Research-proven strategies have been presented to effectively improve memory, enhance recall, and increase retention of information. As few or as many such strategies are differently needed by different people. Although there are no guarantees when it comes to preventing memory loss or dementia, some simple ways exist to sharpen memory.

Sidebar 1 - Emotional Significance Enhances Memories

A normal function of emotion is to enhance memory in order to improve recall of experiences that have importance or relevance for our survival. Emotion emphasizes certain aspects of experiences to make them more memorable. It affects all the phases of memory formation: registering information, processing and storage, and retrieval.

Emotional learning to strengthen memory

- **Attention:** Attention guides the focus to select what is most relevant for our lives; it is normally associated with novelty. Nothing focuses the mind like surprise. Emotional intensity acts to narrow the scope of attention so that a few objects are emphasized at the expense of many others. Focusing upon a very narrow area allows for an optimal use of our limited attentional capacity.

- **Memory consolidation:** Most of the information we acquire is forgotten and never makes it into long-term memory. When we learn a complex problem, the short-term memory is freed up and the action becomes automatic. Emotionally charged events are remembered better than those of neutral events. The stress hormones epinephrine and cortisol enhance and consolidate memory. Dangerous situations are imprinted with extra clarity so that they may be avoided in the future.

- **Memory recall:** Memories of painful emotional experiences linger far longer than those involving physical pain.

- **Priming:** Past memories are often triggered or primed by one’s environment. Priming refers to activating behavior through the power of unconscious suggestion. The goal stored in long-term memory is retrieved and placed in short-term memory.

- **Mood Memory:** Current emotional state facilitates the recall of experiences that had a similar emotional tone. Moods bring different associations to mind.

- **Blanking out:** Stress can lead to memory deficits, such as the common experience of mentally blanking during a high-pressure exam or interview. In general, anxiety influences cognitive performance in a curvilinear manner (this is the 'Yerkes‑Dodson law'). When levels of arousal are either too low or too high,

performance is likely to suffer. The optimal situation is moderate arousal.

- **Duration neglect ('peak-end rule'):** The way we remember events is not necessarily made up of a total of every individual moment. Instead, we tend to remember and overemphasize the peak (best or worst) moment and the last moment, and we neglect the duration of an experience.

In sum: Much of learning takes place in the form of emotional learning, and to make our memory stronger, it helps to attach emotional significance.

Stroke and Memory Loss

Memory loss following a stroke often occurs because the areas of the brain responsible for memory encoding and retrieval, primarily the hippocampus and the adjacent structures in the medial temporal lobe, get damaged. Depending on the severity and location of the stroke, memory loss can range from mild forgetfulness to severe anterograde amnesia, where the person cannot form new memories. For instance, a stroke affecting the left side of the brain may lead to difficulties in remembering verbal information. In contrast, a stroke affecting the right side may affect the recall of visual or spatial information.

Coping with memory loss after a stroke can be a daunting and emotionally overwhelming journey. Approximately one-third of patients are affected by memory loss and profound cognitive changes within the first year after their stroke, leading to confusion, frustration, and despair. However, understanding the emotional impact of memory loss is an important factor in dealing with its challenges.

- **Emotional impact**

Memory loss after a stroke is a complex, multifaceted issue that often provokes a profound emotional response. The sudden inability to recall familiar faces, cherished memories, or daily routines presents emotional challenges. Specifically, it can cause fear, confusion, and frustration for stroke survivors and their loved ones.

- **Emotional response**

Recognizing the emotional response to memory loss is critical because it lays the foundation for effective coping strategies.

◦ **Sadness:** It ranges from mild unhappiness to deep, clinical depression. The inability to remember valued memories or even simple, everyday tasks can trigger feelings of loss and grief.

◦ **Anger:** It can be directed toward oneself for perceived failings or others for their inability to understand the depth of the struggle. It is a natural response to a complex and unexpected situation. While anger might be perceived as a negative emotion, it can be channeled positively, using it as a motivation for change rather than a source of self-destruction.

◦ **Fear:** This debilitating emotion can lead to worsened anxiety and depression. The fear of losing oneself, and the fear of the unknown future, can be paralyzing, preventing the individual from progressing in their recovery journey.

- **Coping Strategies**

Despite the difficulties posed by memory loss after a stroke, various coping methods and techniques can help manage the symptoms. These strategies are intended to compensate for memory deficits and enhance memory performance:

◦ **Routines and checklists:** They can provide structure and predictability, reducing the demand for memory.

◦ **Memory aids:** Calendars, diaries, note-taking, and electronic reminders can help with remembering appointments, tasks, or important information.

◦ **Associating new information with something familiar (or elaborative encoding):** This technique can make it easier to remember.

◦ **Lifestyle changes:** Regular physical exercise, a balanced diet, adequate sleep, and stress management have all been shown to benefit cognitive health and support memory function.

For many, memory loss following a stroke becomes a silent thief, quietly stealing precious moments and personal histories. However, through compassion, understanding, and knowledge, stroke survivors and their loved ones can navigate the emotional challenges of post-stroke memory loss, turning obstacles into opportunities for growth and resilience. Remember, emotional reactions to memory loss are normal and part of the recovery journey. They are not a sign of weakness but rather a testament to the strength and adaptability of stroke survivors.

In sum: Post-stroke memory loss impacts about a third of patients. Memory loss and other cognitive impairments often depend on stroke severity and location. Sadness, anger, and fear are common emotional responses to post-stroke memory loss.

Sidebar 2 - Respiration Modulates Cognitive Function and Memory

Breathing, an involuntary reflex, may shape cognitive function and memory. During off-line brain states such as sleep, respiration is known to coordinate hippocampal activity, acting as a memory modulator and playing a role in memory consolidation. Mice experiments have shown that certain components of central respiratory activity (such as frequency) during on-line encoding contribute substantially to shaping hippocampal ensemble cell dynamics and memory performance.

Thus, breathing could potentially be actively recruited during on-line memory encoding. The correlation between breathing patterns and memory encoding may yield innovative approaches in the treatment of memory-related disorders, such as Alzheimer's disease and other forms of dementia. Customized respiration exercises might be developed as part of therapeutic regimens to enhance cognitive function.

Sidebar 3 – Vision and the brain

Eyes tell much more than just where one is looking. They provide valuable insights into thoughts and underlying brain health. Basic eye movements such as, for example, following a dot across a screen, can inform of the current status of brain health. The ability to process and perceive visual motion can be read-out in eye movements, which can also inform how brain circuits are performing. Similar to a muscle, the brain circuitry can strengthen over time.

Vision loss is associated with cognitive impairment

Visual impairment increases the risk of cognitive decline and dementia for older adults. One study concluded that poor vision may have led to up to 100,000 cases of dementia in the U.S. In addition:

- **Worse vision is associated with more rapid cognitive decline:** Specifically, worse visual acuity and impaired depth perception are associated with greater declines in language and memory, whereas worse contrast sensitivity is associated with declines in language, memory, attention, and visuospatial ability.

- **Vision loss is associated with cognitive decline patterns:** Patterns of cognitive decline in older adults may differ by the type of vision loss they may experience.

- **Impaired contrast sensitivity is associated with a wider range of cognitive decrement.**

There are several possible reasons why visual impairment is associated with cognitive decline. There are essentially two possible causal pathways or, possibly, their combination:

- **The common causal pathway:** Having a shared pathology underlying both vision and cognitive impairments, such as nerve or vascular disease, is a possibility.

- **The sensory loss consequence pathway:** Here, vision loss may be associated with cognitive decline through conditions known to affect cognition, such as depression, social isolation, decreased engagement in cognitively stimulating activities, and increased cognitive load due to the greater dedication of cognitive resources to visual processing.

- **The combined pathway:** A combination of the above two mechanisms may likely contribute to the greater cognitive decline noted in older adults with vision loss.

Tips for eye and associated brain health

The following recommendations have been provided by the National Eye Institute (NEI) for eye health that may also help your brain health:

- **See an ophthalmologist regularly:** Correcting poor vision with eyeglasses or getting cataract surgery can help prevent diabetic eye disease through early detection and reduce the risk of cognitive impairment. A recent study concluded that one of the easiest ways to reduce the risk of dementia is by correcting poor vision.

- **Eat a healthy diet:** The American Academy of Ophthalmology (AAO) recommends regularly consuming green leafy vegetables, fish, and fruits to provide the nutrients that the eyes need, slow down the rate of cognitive decline, and reduce the risk for dementia.

- **Cardiovascular exercise:** Cardiovascular exercise can help manage chronic health conditions such as diabetes, which can damage the vessels in the retina, leading to visual impairment and, in some cases, even blindness and also increase the risk of dementia. Even in the absence of diabetes, studies have found that regular exercise can help maintain good cognitive function over time.

Sidebar 4 – Memory and mental health

Memories can be immensely powerful but, for people struggling with mental health conditions, that power can be a burden. Because memory has an important role in pathological thinking and behavior, however, what scientists and clinicians have learned about memory can also be key to helping people recover from mental illness.

Memory and common mental disorders

Widespread mental health conditions such as depression, substance use disorders, and anxiety disorders have complex causes that differ substantially. Yet, it is clear that each is characterized, in some ways, by how memory works in the people who suffer from them.

Can stress impair memory?

Stressful situations can result in strong future memories about the experience. But, during a stressful event, remembering information can be more challenging than usual. Over time, chronic stress and elevated levels of stress hormones like cortisol may have a detrimental effect on the ability to remember. In addition, the

experience of psychological stress is well established as a force affecting how we remember. Taking steps to reduce stress is one way people can seek to preserve memory ability.

Can depression make one forgetful?

Depression is associated with multiple kinds of cognitive impairment, including forgetfulness— though memory difficulties often resolve after a depressive episode is successfully treated. A depressed person may also show other memory differences, including relatively weak memory for positive events, stronger memory for negative ones, and relatively general (rather than specific) recollections about personal experiences. Depression has been linked with reduced volume in the hippocampus, a part of the brain that is important for memory.

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