

1.2 MODAL MODEL OF MEMORY

In the modal model of memory, memory consists of three stores: a sensory register, short-term memory (STM), and long-term memory (LTM).

Information remembered with conscious effort uses explicit memory, while information remembered unconsciously and effortlessly uses implicit memory.

Learning Objectives:

- Describe how each store has its own characteristics in terms of capacity and duration.
- Describe the differences between procedural, episodic, and semantic memory.
- Determine whether procedural, episodic, and semantic memories are explicit or implicit.

2023 Subject Outline | Stage 1

The **modal model of memory** uses the stages from the information processing model but defines three different memory stores with distinct properties. Atkinson and

Shiffrin proposed the 3-stage model of memory in 1968, which has since been developed by psychologists into the model presented below.

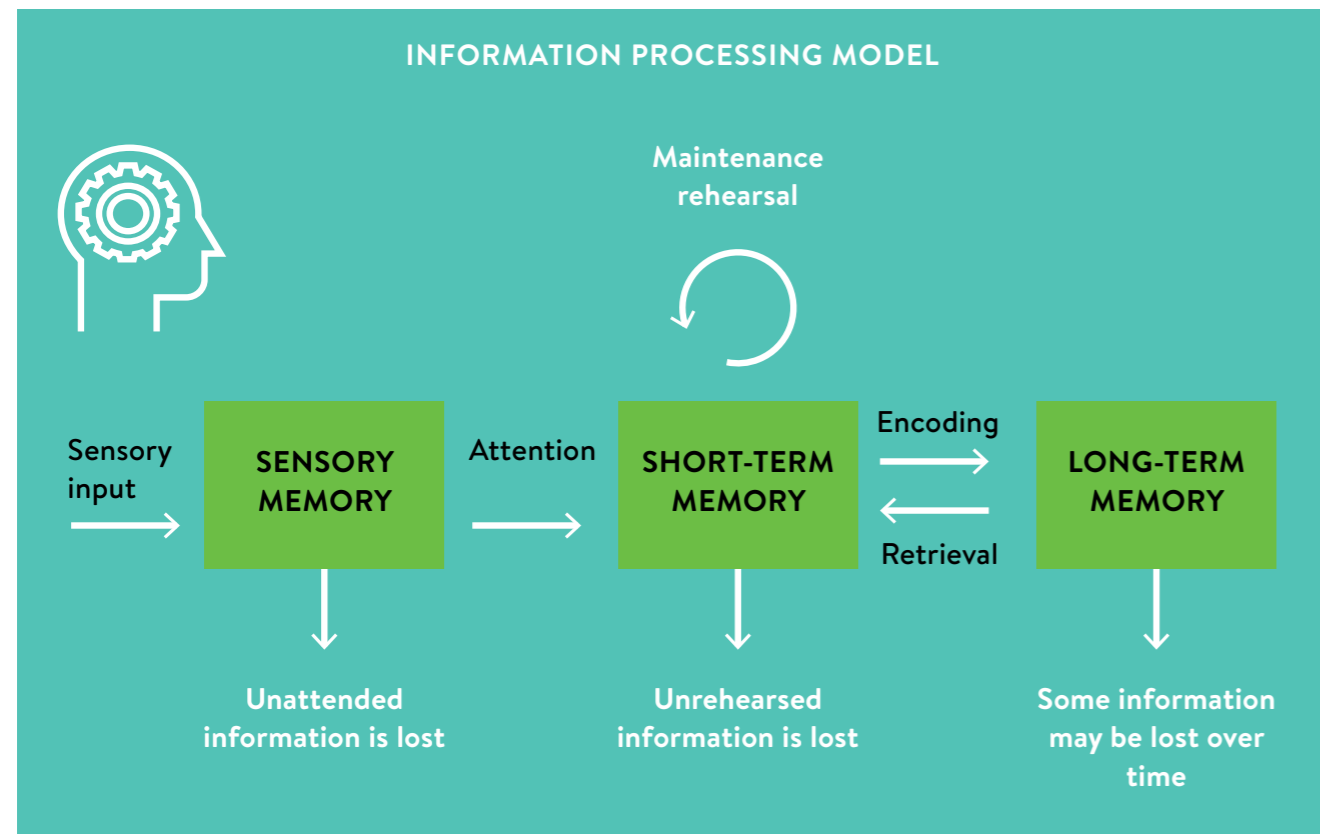


Figure 1.2.1: The Information Processing Model of Memory according to Atkinson and Shiffrin.

Sensory Register

We experience sensory input in a vast variety of ways. You have probably learned about the basic five senses that humans experience, but there are many more that give us vital information. For example, the vestibular sense helps us to know what orientation we are in relation to gravity. However, we would be overwhelmed if we paid attention

to all of our sensory information at once, so we only pay attention to that which is deemed as important. This must occur within a few seconds or the information is lost. Imagine watching a sparkler trace through the air. You can recall the shape for a couple of seconds using iconic (visual) memory. Likewise, when you hear someone speak then are asked what they just said, you can recall the last few seconds of information using echoic (auditory) memory.

Short Term Memory

If attention is paid to the sensory information, it is moved to the **short-term memory store**. This can hold about 7 ± 2 items of information for between fifteen to thirty seconds duration. This has a large capacity but the information is easily lost to prevent the mind from overload. The most researched areas of this store include auditory (hearing), spatial (positioning in space) and visual. However, this information can come from all of the senses.

Research on the short-term memory started as early as 1887, when Joseph Jacobs created a digit span test similar to the activity below. He asked people to recall a string of numbers, increasing by one each time until no more could be remembered. He found that an average of 7 digits were able to be recalled accurately. George Miller (1956) introduced the idea of 'chunks' of information and added that we could remember 2 less than or 2 more than 7 of these in our short-term memory.

STUDENT ACTIVITY 1

Instructions:

1. Find a partner and decide who will be the participant and experimenter. Make sure the participant cannot see the following charts.
2. The experimenter reads one line out at a time, while the participant immediately recalls the line out loud.
3. Keep working through the lines on the chart in this way until the participant's recall is no longer accurate. Record how many digits were recalled correctly.
4. Repeat the same process for the lines of letters. Record how many letters were correctly recalled.
5. Compare your findings to those of Jacobs.

NUMBER CHART	LETTER CHART
2	H
64	AL
109	NUW
3856	SHFO
27185	OGBSY
751349	SBKEYA
9461825	WOVUABR
29461846	OCNSLWBAH
401735298	PWEHNRUNLS
8372015634	KSNWUGBAPQL
910375617392	CUSHEKFZSMAO

STUDENT ACTIVITY 2

Read the following list of letters quickly, then cover them up and write them down in the same order as they appear on the page.

XGUWZSPJQLTBFMK

Now do the same with this list.

BAQ KIB MEP GUJ VOF

Now this.

BIT KEG SUN LAW TOY

The first string of 15 letters is nonsensical and difficult to remember, but the second gives 5 chunks that are easier to recall as separate pieces of information. The third is easier again as we can assign meaning to the chunks.

In 1959 Peterson and Peterson conducted an experiment to test short-term memory duration when rehearsal of the information was prevented. They provided participants with trigrams (groups of three consonants) to recall, then asked them to count backwards by threes or fours. This is known as a distractor task and aimed to prevent the participants from repeating the trigrams over and over. They then tested participant recall at different time intervals and found the results shown in the graph below.

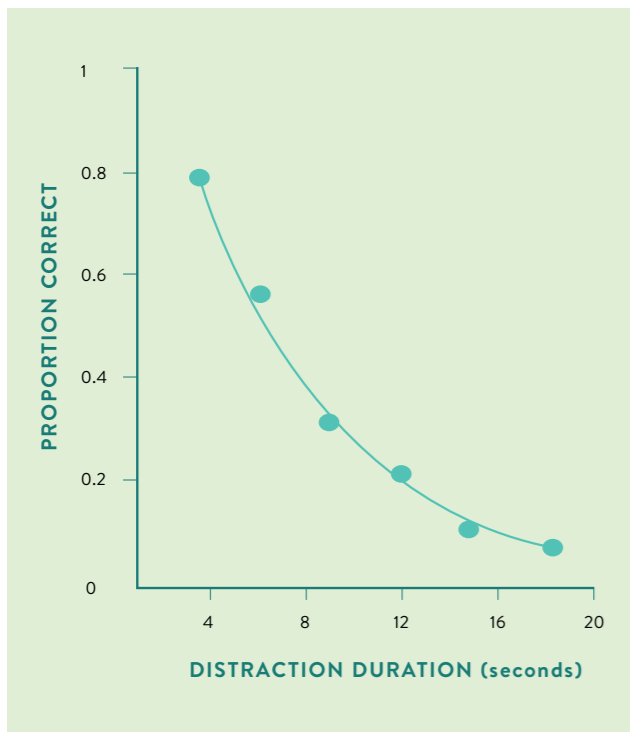


Figure 1.2.2: Proportion of consonant trigrams correctly recalled as a function of task duration from Peterson & Peterson, 1959.

The results showed that after only 18 seconds, correct recall had declined to less than 10%. However, when rehearsal is not prevented Atkinson & Shiffrin (1971)

proposed that the duration of the short-term memory could extend to as long as 30 seconds.

Rehearsal

There are two types of rehearsal recognized by psychologists: maintenance rehearsal and elaborative rehearsal. **Maintenance rehearsal** consists of repeating the information over and over either verbally or in your head, while **elaborative rehearsal** involves reorganizing new information in a meaningful way. Both are used as methods of encoding information from the short-term memory store to move into the long-term store. We also now know that rehearsal strengthens the neural networks relating to these concepts, making them easier to recall later.

Long-term Memory

Once information has been encoded, it moves to the **long-term memory store**. This has an unlimited capacity, but information can fade over time if it is not rehearsed frequently. This means that the duration of the long-term store is theoretically unlimited, but in reality we often forget information over time. The way a memory is encoded also impacts its longevity, along with emotional and motivational factors.

In 1975 Bahrick, Bahrick and Wittinger tested 392 students graduating from university on the names of their classmates from High School. The recall rate was 90% up to 15 years later, but had only declined to 60% after 48 years. As the task involved matching names and faces, it was concluded that with sufficient meaning assigned to information the long-term memory could almost have a life-time duration.

	SENSORY REGISTER	SHORT-TERM MEMORY (STM)	LONG-TERM MEMORY (LTM)
Capacity	Depends on selective attention	7 ± 2 items (chunks) of information	Limitless
Duration	A few seconds	Varies from 15 to 30 seconds, increases with rehearsal	Limitless, aided by rehearsal, otherwise can be lost over time
Function	Registers 'raw' sensory information	Receives info. from the sensory register, encodes it using info. from the LTM	Stores huge amount of information over a long period of time, aids learning

Figure 1.2.3: Summary of the features of each memory store.

CHECKING FOR UNDERSTANDING

Complete the following cloze activity using the words provided below.

The modal model of _____ theorises three different memory stores. The first is the sensory _____ which filters for _____ information that is important. Less important information may be lost, however, if attention is paid it is first stored in the _____ memory. If this information is given enough _____ rehearsal and is properly _____ it will be passed on to the _____ memory store. If not, the information will only last a short time before it is lost. Once in the long-term memory it may be _____ later or be lost over time.

WORD BANK

encoded	short-term	long-term	memory
retrieved	maintenance	register	incoming

TYPES OF LONG-TERM MEMORY

Psychologists have categorized different types of long-term memory. Information remembered with conscious effort uses **explicit memory** (the 'what'), while

information remembered unconsciously and effortlessly uses **implicit memory** (the 'how'). These can also be subdivided into further types as seen in Figure 1.2.4.

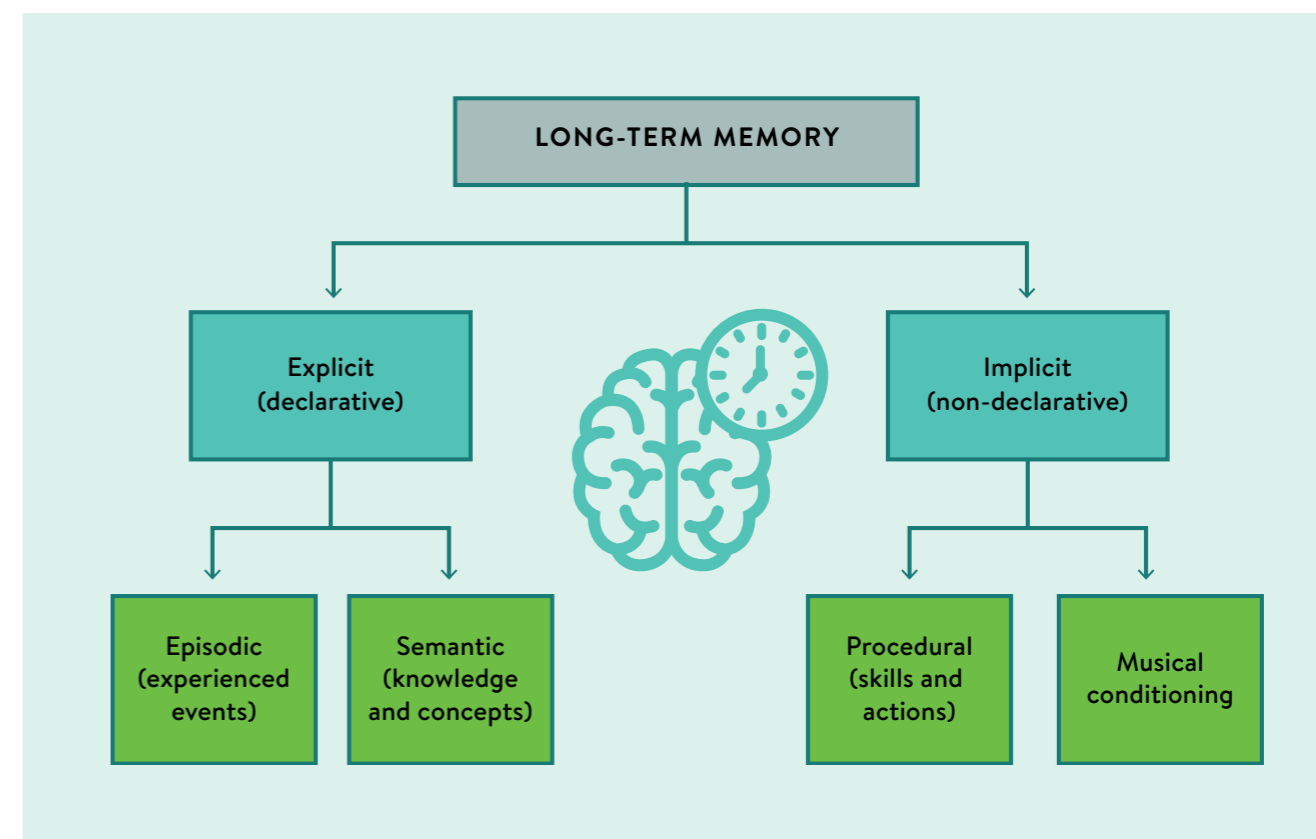


Figure 1.2.4: Sub-types of Long-term Memory.

EPISODIC MEMORY

Tulving in 1972 proposed that there were other types of long-term memory including episodic memory. This refers to our memories of events we have experienced in our lives and the details that surrounded this event. You can

probably recall a recent birthday including where, how and with whom you celebrated. This is a type of explicit memory because you need to consciously be primed with the word 'birthday' in order to bring the memory of the event to mind.

SEMANTIC MEMORY

This is our stored knowledge of general facts and ideas. This usually involves conscious effort to learn the information and may require rehearsal if it is not related to our emotions. Semantic memory is a type of explicit memory because the knowledge will not be recalled unless it is needed. For example, you may be asked for the capital of a country as part of a quiz and have to search your memory for the answer.

PROCEDURAL MEMORY

This is our memory of how to carry out skills and actions. You will have used this when learning to drive a car or ride a bicycle for the first time. It also requires conscious effort to learn but then becomes habit after repetition making it a type of implicit memory.

CONDITIONING (LEARNING)

This refers to the process of being conditioned to have a specific response to a stimulus. This either involves strong emotions being associated with a single event or repetition of a stimulus being paired with another stimulus to create the desired response. An example of conditioning is shellshock which was experienced by people coming back from wars, where certain sounds might trigger a panic response. This was not consciously learned but will be recalled implicitly as they have no control over their body's physiological stress response.

Additions to the model

WORKING MEMORY

The Modal Model of Memory has been refined by psychologists such as Baddeley and Hitch to include an addition to the short-term memory in the functions of the **working**

memory. They proposed that people had a separate system to process visual information (the **visuo-spatial sketchpad**) from what was used in processing auditory information (the **phonological loop**). These two systems are managed by the **central executive** which allocates memories to one of the systems. This explained why people were able to listen to one stimulus while also taking in visual cues, however, it is much more difficult to listen to two stimuli at the same time and make sense of both.

SCIENCE AS A HUMAN ENDEAVOUR



The Modal Model of Memory has had many refinements in recent decades. Investigate the **Development and Applications** of the model.

Development and Application

- Discuss how developments in research have led to advancements in the modal model of memory.
- Discuss any research techniques or new technologies that have allowed this research to make new findings.
- Explain how the new versions of the model might be used in an educational setting.

HELPFUL ONLINE RESOURCES



Read about how technology is being used in the latest research in Memory:
<https://tinyurl.com/9pnjh7hh>



CHECKING FOR UNDERSTANDING

Fill in the boxes below with examples of each type of long-term memory that are personally relevant to you.

Episodic Memory	Example: You remember where you were when you heard a famous person had died.
Semantic Memory	Example:
Procedural Memory	Example:

CASE STUDY: CLIVE WEARING

Clive Wearing is commonly referred to as 'the man with the 30 second memory' due to the amnesia he suffers after a brain infection contracted over 35 years ago.

Prior to his illness, Wearing was an accomplished musician and conductor, living in London with his wife Deborah. He worked for the BBC and created musical scores for the London Opera Centre.

In 1985, Wearing contracted meningoencephalitis, an infection in the meninges, the thin layers of tissue that surround the brain. The disease is often fatal when left untreated because neurons are harmed by both the infection itself and the inflammation it causes. While some sufferers of the disease recover completely without ongoing symptoms, some severe cases can cause long-term, permanent brain damage, as it did for Clive Wearing.

Due to the attack on the central nervous system, Wearing was left unable to store new memories. He also struggled to regulate his emotions and often exhibited unstable moods.

Much of the damage caused by the encephalitis occurred to the hippocampus, a structure in the temporal lobe responsible for the formation of long-term memories. Because of this, Wearing suffers from total amnesia, rendering him incapable of forming new memories. Wearing's short term memory lasts between seven and thirty seconds.

Wearing spends his day believing that he just woke up, as he cannot remember what he has done prior to that moment in time. He believes that he has just come out of the coma that was the result of his encephalitis, constantly asking why he has not seen a doctor to assist with his condition. He cannot maintain conversation as he lacks the ability to follow the flow of dialogue and remember the topics being discussed.

Just one year before suffering from encephalitis, Clive married Deborah, his second wife. He has children from a previous marriage but cannot remember their names nor the details of their lives. His love for Deborah is obvious as each time she walks into a room, Wearing believes he is seeing her for the first time. He greets her with the joy and passion of a man who desperately missed his lover during a long absence.

Despite having no memory of his time as a musician or composer, and no longer being able to identify pieces of music based on their titles, Wearing is still able to play the piano, as well as sight-read music.

When interviewed for a documentary in 2005, Wearing was asked if he missed his old life, to which he replied: "Yes. But I've never been conscious to think that. So, I've never been bored or upset. I've never been anything at all, it's exactly the same as death. No dreams even. Day and night, the same."



Figure 1.2.5: Clive Wearing and his wife, Deborah.

SCIENCE AS A HUMAN ENDEAVOUR

Human memory and computer models of memory such as those used in Artificial Intelligence (AI), have both been researched widely throughout the last few decades. There is a growing field of study called Computational Neuroscience that encompasses these ideas. Research and write a discussion about how these developments in computer memory models have advanced knowledge about human memory. Useful websites:



<https://tinyurl.com/2mcjueuv>



<https://tinyurl.com/yvtx6ptv>



<https://tinyurl.com/mudey92p>



<https://tinyurl.com/3dwyeezx>

HELPFUL ONLINE RESOURCES



The Real 50 First Dates: Meet the man with a 30 second memory | 60 Minutes Australia: <https://tinyurl.com/292v6drh>



SCIENCE INQUIRY SKILLS (SIS)

Practise designing an experiment testing recall for different levels of processing using the steps below.

1. Choose a type of research design.

- Repeated Measures (same participants are used in each condition)
- Matched Pairs (participants matched on a particular measure are put into different conditions)
- Independent Groups (different participants are used in each condition)

2. Write a hypothesis for this experiment.

Participants who _____
will show _____

3. Write a detailed method for each condition.

Structural Processing Condition:

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Phonetic Processing Condition:

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Semantic Processing Condition:

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4. Explain how the results will be measured and recorded.

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5. Describe how the results will be graphed.

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1.4 DISPLACEMENT THEORY OF FORGETTING

Forgetting information from short-term memory (STM) can be explained.

Learning Objectives:

- Use the theory of displacement to explain the forgetting of information from STM.

2023 Subject Outline | Stage 1

There are many theories in psychology around why we forget information. The displacement theory uses the concepts of the primacy and recency effects and focuses on the STM. The **primacy effect** suggests that we remember information near the beginning of a set due to our use of rehearsal to store it in the long-term memory, while the **recency effect** means that we also remember information near the end of a set using our short-term memory. Murdock (1962) obtained similar results to the graph below using recall of a list of words presented for one or two seconds. He found that the probability of recall related to the position of the word in the list (its serial position). It was hypothesized that when new information enters the STM, the older information is replaced by the new. This is what is meant by 'displacement'. The theory of displacement proposes that due to the limited capacity of the STM, once this store is full, new memories will replace the older memories.

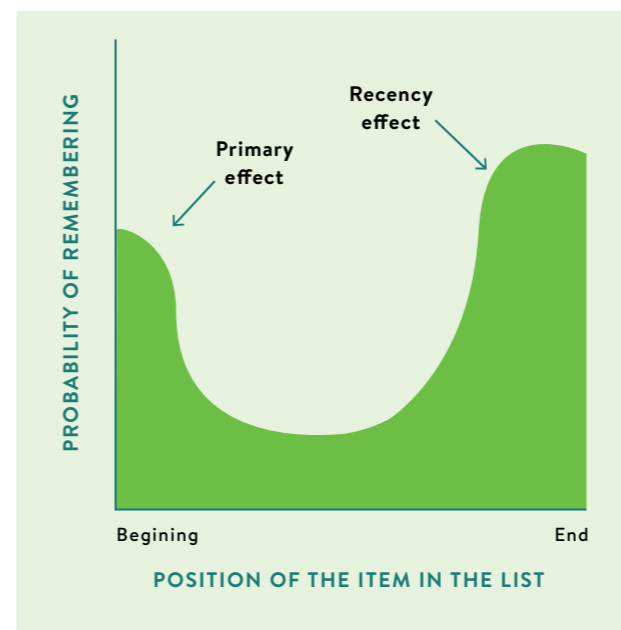


Figure 1.4.1: Serial position effect curve.

SCIENCE INQUIRY SKILLS (SIS)

Design and Deconstruct Investigation ideas:

- Investigate Primacy and Recency effects in different types of learning tasks.
- Investigate capacity of STM when under different distraction conditions.
- Investigate duration of STM with different modes of stimuli (e.g. hearing versus seeing information.)

Note: For a SACE Stage 1 student investigation design the outcome must be uncertain so a variable must be used that has not been previously researched.

HELPFUL ONLINE RESOURCES



Watch the video about how the serial position effect can be explained in terms of the modal model of memory.
<https://tinyurl.com/bdhdhezr>

1.5 OTHER THEORIES OF FORGETTING

Forgetting information from long-term memory (LTM) can be explained in a number of ways.

Learning Objectives:

- Explain the difference between proactive and retroactive interference.

- Use the theory of retrieval failure to explain forgetting from LTM.
- Use the decay theory to explain the forgetting of information from LTM.
- Explain forgetting from LTM using the lack of consolidation theory

2023 Subject Outline | Stage 1

Other theories of forgetting focus on the LTM store. One explanation for forgetting information lies in **interference theory**. Interference theory suggests that retrieval may be impacted by similar information being confused with the memory. **Proactive interference** occurs when previously learned information interferes with the new memories being created. An example of this might be when you drive to the wrong workplace because you worked there a year ago, but no longer do. **Retroactive interference** occurs when the new information being learned interferes with what was already known. An example of this might be learning a word in French, then later learning the German word for the same item but forgetting the French translation. Both of these ideas suggest that we confuse our information so that it is no longer accurately recalled. However, retrieval failure may occur in other ways.

Retrieval failure is said to occur when we don't receive the correct retrieval cues. **Retrieval cues** are stimuli in our environment that were present when the memory was formed. These could be visual cues such as the face of the person in front of you or other sensory cues such as the scent of a perfume you were wearing at the time. In 1975 Godden and Baddeley explored the impact of different contexts on recall. They asked scuba divers to learn a list of words on land or under water. They were then asked to recall the words in either of these contexts using a repeated measures experimental design. The participants showed better recall when the context for learning matched the context for recall, i.e. learning under water was recalled better under water than on land and learning on land was recalled better on land than under water. This suggests that **context-dependent cues** are important to recall and without them we may find ourselves searching for information we are sure we know. Have you ever walked into a room only to forget why you have come there? Often when you return to the location where the thought occurred to you, you will be able to remember what it was.

It has also been shown that the state of consciousness in which we learn information can impact our recall. This is thought to happen at the encoding stage and the internal



Figure 1.5.1: A scuba diver like those used in the study by Godden and Baddeley into context-dependent cues for memory retrieval.

stimuli in our bodies are known as **state-dependent cues**. Experiments using drugs have been used to show that people who are under the influence of a specific drug will recall information better when they were under the same drug's influence as it was learned. We can also apply this knowledge to mood.

Decay Theory As far back as 1885, Ebbinghaus theorized that the brain's ability to recall information over time

SCIENCE INQUIRY SKILLS (SIS)

Explain why research into state-dependent memory cues on humans and animals may be unethical.

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without rehearsal decayed in an exponential **forgetting curve**. This means that the loss of information is rapid in the first few days, but slows to a lower rate beyond that time and continues asymptotically, never fully fading.

Although Ebbinghaus conducted his experiments on himself only, this curve has since been replicated in further

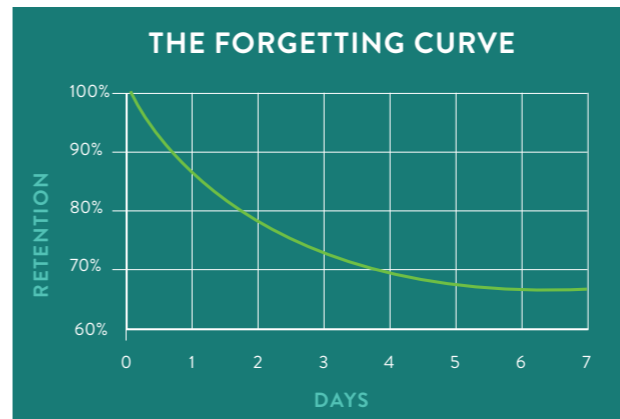


Figure 1.5.2: Ebbinghaus' Forgetting Curve for Long-term Memory.

studies and is widely used to represent human forgetting. The decay theory states that without rehearsal or revisiting information, our memories will fade over time. This means that they will prove more difficult to retrieve and that their accuracy will be diminished as time passes.

The **consolidation theory** of memory suggests that rather than decaying instantly, information in the LTM actually needs time to cement itself into stored information. This means that if we don't give sufficient time for a memory to consolidate, it may not be remembered. An example of this might be revising for a test just before going to sleep. This supposedly gives your brain enough time to consolidate the information during the night and should be remembered well in the morning. The theory came about due to cases of brain damage impacting newer memories, but not those formed earlier in life. It is thought that structural changes in the brain may underlie this phenomenon. This leads us to understand that there are certain biological impacts on forgetting.

CHECKING FOR UNDERSTANDING

Fill in the table below with definitions of the term and examples of your own.

TERM	DEFINITION	EXAMPLE
Proactive interference		
Retroactive interference		
Retrieval cues		
Context-dependent cues		
State-dependent cues		
Memory Consolidation		

SCIENCE INQUIRY SKILLS (SIS)

Design and Deconstruct ideas:

- Investigate proactive and/or retroactive interference
- Investigate Ebbinghaus's forgetting curve (duration of LTM)
- Investigate the impact of context-dependent cues on recall

Note: For a SACE Stage 1 student investigation design the outcome must be uncertain so another variable must be introduced that has not been previously researched.

1.6 BIOLOGICAL CAUSES OF FORGETTING

There are also biological explanations for forgetting.

Learning Objectives:

- Describe how memory problems in people with Alzheimer's disease change over time.

- Explain the memory problems in people with Alzheimer's disease.

2023 Subject Outline | Stage 1

All people experience **cognitive decline** as they age that decreases their ability to learn, solve problems and use their memory. However, **Alzheimer's disease** has a clear biological cause and is characterized by a decline in memory function. Alzheimer's disease is thought to be caused by an abnormal build-up of amyloid plaques around brain cells and tau tangles within brain cells. These two abnormal forms of proteins have been shown to be more prevalent in the brains of people who have died from Alzheimer's disease, but it is still unknown how they are caused. What we do know is that people with the disease tend to suffer from an early decline in cognitive functions such as memory and thinking skills. Over time this can lead to an inability to carry out simple tasks such as comprehending language, carrying out routine tasks and swallowing food. There is no cure or treatment for the disease, and it affects up to 1 in 10 Australians over the age of 65 years of age and up to 3 in 10 Australians over 85 (healthdirect.gov.au).

The disease initially affects the outer layer of the brain which is responsible for learning and short-term memory, but moves progressively inwards to impact other functions such as language, reason and social behaviour, before moving to those parts important for body regulation. The Hippocampus is a region in the brain that plays a significant role in memory and is heavily affected as the disease advances. It is understood that Alzheimer's disease causes a loss of connections between neurons over time.

HELPFUL ONLINE RESOURCES



Watch the following video to combine your understanding of Neuropsychology with the causes of Alzheimer's disease.
<https://tinyurl.com/mths4s5x>

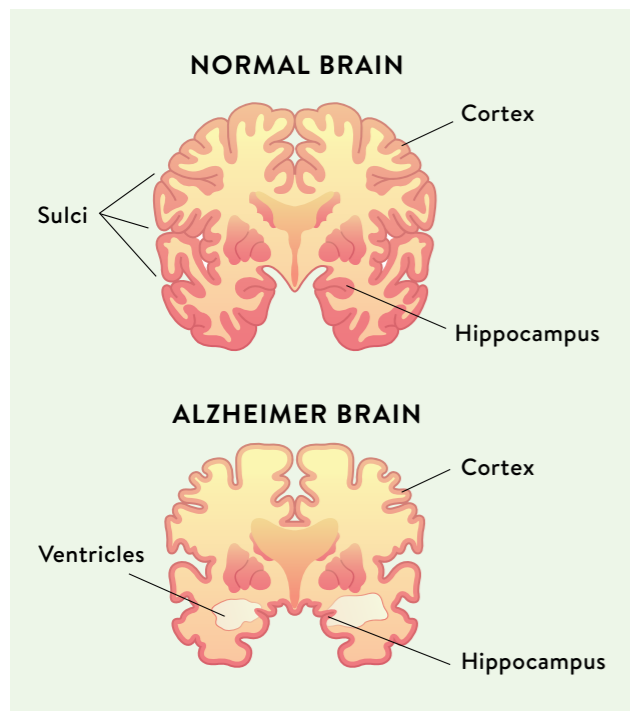


Figure 1.6.1: changes in the brain due to Alzheimer's Disease.

The symptoms for Alzheimer's disease can begin in mid-life (usually mid-60s) and typically consist of memory issues, confusion, mood swings and changes in social skills. In the first stage of the disease the short-term memory is impacted and recall of recent events can be difficult. People with this mild level of Alzheimer's disease will experience symptoms such as confusion, disorientation and find it difficult to grasp complex ideas or adapt to changes.

Throughout the second stage, patients with Alzheimer's disease may experience more significant impacts such as forgetting to finish routine tasks, forgetting names of family members and friends, and becoming repetitive. In worse cases they may experience poor decision-making, emotions such as anger and frustration and neglecting important tasks such as attending to personal hygiene and eating. They can also experience fluctuations in functioning such as the ability to recall events which may be normal one day and not the next. For example, not recognising family members but remembering the name of their primary school teachers and neighbours where they grew up.

HELPFUL ONLINE RESOURCES



Find out more about Alzheimer's disease and the symptoms associated with each stage at the Dementia Australia website.
<https://tinyurl.com/2974h2p8>



Alzheimer's patients often have trouble recalling recent events, but can recall earlier events in their lives, which can provide comfort as they relive familiar times. In some countries, facilities have been established to recreate past settings, providing comfort and familiarity for patients. However, for family members, it can be challenging to witness their loved one's decline as they become increasingly dependent on others for daily tasks.

The final stage of the disease may see people losing their long-term memories of important life events or earlier life experiences. Over time the neural pathways are no longer available which ceases recall permanently. They can lose their ability to use and understanding language entirely and have difficulty with basic movement. At this point people are almost completely reliant on others to care for their daily needs.

HELPFUL ONLINE RESOURCES



Watch this video about a 1950s town that has been created to care for Alzheimer's patients.
<https://tinyurl.com/msf7t3h6>



SCIENCE AS A HUMAN ENDEAVOUR



New research in Alzheimer's disease is being carried out all the time. Find an article about new research in this area. Explore it for the SHE aspects listed below.

Communication and Collaboration

- Investigate who funded the research and whether more than one institution was involved. Explain how this constitutes collaboration between researchers.
- Detail any collaborations or funding that may have come from other stakeholders including those who may have been impacted by the illness.
- Describe how the findings were reported and explain the aim of sharing scientific findings with other researchers and the wider community.
- Describe the different skills and experience of researchers involved showing how different disciplines work together to create evidence.

Development and Application

- Discuss any research techniques or new technologies that were developed by others and used in this research. Explain how this has advanced psychological understanding about Alzheimer's disease.
- Explain how the research might be used in the future either to support those living with the disease or in forming treatments or preventions.

Influence

- Explain how economic and sociocultural impacts of Alzheimer's disease may have led to the research being conducted.
- Describe how the research findings might impact economic and sociocultural perspectives at a local, national and global level.
- Describe any positive, negative or unexpected consequences of the research findings.