

Memory

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1. Memory: processes, physiological basis, stores and types
2. Measuring memory, forgetting and mnemonics

1 Memory: processes, physiological basis, stores and types

Memory is the system that encodes, stores and retrieves information; it leaves a physical memory trace in the brain that is fixed by consolidation (the hippocampus is key), it flows through sensory, short-term and long-term stores (Atkinson–Shiffrin, 1968), and long-term memory holds declarative (episodic, semantic) and non-declarative (procedural, priming) knowledge. Learning curves, Ebbinghaus and study habits are in EDU-LR-01; measuring memory, forgetting and mnemonics are in PSY-MM-02.

Core facts

- **Memory:** retention of learning or experience over time; it has a **neural, chemical and biological** basis.
- **Three processes (stages):**
 - **Encoding:** information is taken in and turned into a form the system can use (a code: visual, acoustic or semantic).
 - **Storage:** the encoded information is held over time.
 - **Retrieval:** stored information is brought back into awareness for use (recall is the common name for it).
- Failure at **any** of the three stages leads to "forgetting".
- **Memory trace (engram):** the **physical and chemical change** in the brain that stands for an encoded memory. **Karl Lashley** searched for the engram in rats and concluded it is **spread** across the cortex, not in one spot (law of mass action).
- **Consolidation:** the process by which a fresh, fragile trace becomes **stable and lasting** in long-term memory. A head blow can wipe out the minutes before it (**retrograde amnesia**), because those traces were not yet consolidated.
- **Brain parts:**
 - **Hippocampus** (medial temporal lobe): forms **new declarative memories** and consolidates them; it is not the final store.
 - **Cerebral cortex:** the long-term store of facts and events.
 - **Amygdala:** emotional memories (fear).
 - **Cerebellum** and **basal ganglia:** procedural (skill) memory and conditioned responses.
 - **Prefrontal cortex:** working memory.
- **Patient H.M.** (Henry Molaison): most of both hippocampi and nearby medial temporal lobe tissue removed (1953) for epilepsy; afterwards he could **not form new long-term declarative memories (anterograde amnesia)** but could still learn new **motor skills** (mirror drawing). Studied by **Brenda Milner**.
- **Neural basis of learning: Donald Hebb** (1949): when one neuron repeatedly helps fire another, the connection between them grows stronger (Hebb's rule, popularly "cells that fire together wire

together"); **long-term potentiation (LTP)**: lasting strengthening of synapses after repeated stimulation, seen first in the hippocampus.

- **Multi-store (modal / information-processing) model: Atkinson and Shiffrin, 1968.** Three stores in sequence:

Store	Capacity	Duration	Code
Sensory memory (register)	large	under 1 s (visual) to 2–4 s (sound)	raw sensory copy
Short-term memory (STM)	7 ± 2 items (Miller, 1956)	about 18–30 s without rehearsal	mainly acoustic
Long-term memory (LTM)	practically unlimited	minutes to a lifetime	mainly semantic

- **Sensory memory: iconic** (visual, under a second; **George Sperling, 1960**, partial-report method) and **echoic** (auditory, a few seconds).
- **Attention** moves information from sensory memory into STM; **rehearsal** keeps it in STM and helps move it to LTM.
- **STM**: brief memory for a small amount of information (a phone number dialled once). **Peterson and Peterson (1959)**: with rehearsal blocked, recall fell to about 10% within **18 seconds**.
- **Chunking** (Miller): grouping items into meaningful units raises how much STM holds.
- **Working memory: Baddeley and Hitch, 1974**; STM seen as an active workspace with parts: **central executive**, **phonological loop**, **visuospatial sketchpad**, and (added by Baddeley, **2000**) the **episodic buffer**.
- **Levels of processing: Craik and Lockhart, 1972**; memory depends on **how deeply** information is processed, not on separate stores. Shallow → deep: **structural** (how it looks) → **phonetic** (how it sounds) → **semantic** (what it means). Deeper = better remembered.
- **Types of long-term memory:**
 - **Declarative (explicit)**: facts and events you can state ("knowing that"):
 - **Episodic**: personal events tied to a time and place (my first day in college). **Endel Tulving, 1972** split episodic from semantic.
 - **Semantic**: general knowledge, word meanings, **concepts and rules of logic** (Hyderabad is in Telangana; $2 + 2 = 4$).
 - **Non-declarative (implicit)**: shown in performance, not stated ("knowing how"):
 - **Procedural**: skills and habits (cycling, typing, swimming).
 - **Priming**: an earlier exposure makes a later response easier without awareness.
 - **Classical conditioning** effects and simple non-associative learning (habituation).
- **Autobiographical memory**: memory of one's own life story (mostly episodic). **Flashbulb memory**: a vivid, detailed memory of where one was when an emotional event happened (Brown and Kulik, 1977).

Explained

1. The three processes with one example. You meet a new hostel warden named "Ravi Kumar".

Encoding: you notice the name and link it to a friend called Ravi. **Storage:** the name stays in memory overnight. **Retrieval:** next morning you see him and the name comes to mind. If you never paid attention, the failure was at encoding; if you knew it yesterday and lost it, storage; if it is "on the tip of the tongue", retrieval.

2. Memory trace and consolidation

Term	Meaning	Clue in a question
Memory trace / engram	physical-chemical change that represents the memory	"change in the brain representing an encoded memory"
Consolidation	trace becomes stable over time	"fixing", "stabilising", sleep helps it
Retrograde amnesia	loss of memories from before an injury	old memories lost
Anterograde amnesia	cannot form new memories after an injury	H.M. after surgery

Consolidation takes time (from minutes to years for full storage in the cortex). Sleep, especially deep sleep, supports it. Electroconvulsive shock given right after learning in animal studies disrupts it, which is the classic evidence that consolidation exists.

3. Atkinson–Shiffrin step by step

- A stimulus enters the **sensory register**, which holds an exact copy for a moment.
- Only what we **attend** to passes to **STM**; the rest fades.
- In STM, items are lost in about 20–30 seconds by **decay** or pushed out by new items (**displacement**) unless **rehearsed**.
- **Maintenance rehearsal** (repeating) keeps items in STM; **elaborative rehearsal** (linking to meaning) moves them into **LTM**.
- From LTM, information is **retrieved** back into STM when needed.

4. Evidence for separate STM and LTM

- **Serial position curve:** in free recall of a list, the **first** items are recalled well (**primacy**: rehearsed into LTM) and the **last** items too (**recency**: still in STM). A 30-second delay with counting removes the recency effect but not primacy.
- **Different codes:** STM errors are often sound-alike (B for V); LTM errors are often meaning-alike.
- **Amnesia cases:** H.M. had normal STM but could not form new LTM.

5. Working memory: why it replaced the simple STM box

Part	Job	Example
Central executive	directs attention, controls the other parts	planning steps of a sum
Phonological loop	holds speech-based sounds (inner voice)	repeating a phone number

Part	Job	Example
Visuospatial sketchpad	holds images and spatial layout	picturing the route to the bus stop
Episodic buffer (2000)	joins information into one episode, links to LTM	recalling a scene with sound and sight

STM is a **store**; working memory is a **workspace** that both stores and processes.

6. Levels of processing. In Craik and Tulving's (1975) tests, people judged words in three ways: "Is it in capitals?" (structural), "Does it rhyme with *train*?" (phonetic), "Does it fit the sentence *He met a ___ in the street*?" (semantic). Later, recognition was best for the semantic group. The idea challenged the store model: depth, not time in STM, decides retention.

7. Kinds of long-term memory at a glance

Kind	Also called	Content	Example
Episodic	autobiographical events	what happened to me, when, where	my 10th class result day
Semantic	general knowledge	facts, meanings, concepts, rules	the capital of India
Procedural	skill memory	how to do things	riding a bicycle
Priming	implicit memory	easier processing after exposure	completing "ele___" as elephant after seeing it

Episodic and semantic together are **declarative / explicit**; procedural and priming are **non-declarative / implicit**. Procedural memory survives amnesia better than declarative memory.

8. Where the memory types live in the brain

Memory	Main brain parts
New declarative memories	hippocampus, medial temporal lobe
Stored facts and events	cerebral cortex
Emotional memory	amygdala
Skills, habits, conditioned responses	cerebellum, basal ganglia
Working memory	prefrontal cortex

9. Neurotransmitters and hormones. **Acetylcholine** is important for forming memories; its loss is linked with **Alzheimer's disease**. **Glutamate** (NMDA receptors) is involved in LTP. Stress hormones (adrenaline, cortisol) in moderate amounts make emotional events memorable, which explains flashbulb memories.

Common traps

✗ "Retrieval means storing information." ✓ Storage is **holding**; retrieval is **getting it back** (recall).

X "The memory trace is a mental image." ✓ It is a **physical and chemical change** in the brain (engram).

X "The hippocampus is where long-term memories are permanently kept." ✓ It **forms and consolidates** new declarative memories; long-term storage is in the **cortex**.

X "H.M. lost all his old memories." ✓ He mainly could not form **new** declarative memories (**anterograde** amnesia); old memories and new motor skills largely remained.

X "Multi-store model: Baddeley and Hitch." ✓ Multi-store = **Atkinson and Shiffrin (1968)**; working memory = **Baddeley and Hitch (1974)**.

X "Levels of processing: Atkinson and Shiffrin." ✓ **Craik and Lockhart (1972)**.

X "STM lasts several minutes." ✓ About **18–30 seconds** without rehearsal; capacity **7 ± 2**.

X "Iconic memory is auditory." ✓ **Iconic = visual**; **echoic = auditory**.

X "Rules of logic and concepts are stored in episodic memory." ✓ They are in **semantic** memory.

X "Procedural memory is declarative." ✓ Procedural is **non-declarative (implicit)**; declarative = episodic + semantic.

X "Phonetic processing is the deepest level." ✓ **Semantic** (meaning) is the deepest; structural is the shallowest.

Quick revision

- Three processes: encoding → storage → retrieval.
- Memory trace (engram) = physical-chemical change; Lashley: spread across the cortex.
- Consolidation stabilises traces; hippocampus forms new declarative memories; H.M. = anterograde amnesia.
- Multi-store: Atkinson and Shiffrin 1968: sensory → STM → LTM.
- Iconic (visual, < 1 s, Sperling 1960); echoic (auditory, 2–4 s).
- STM: 7 ± 2 (Miller 1956), about 18–30 s (Peterson and Peterson 1959); chunking extends it.
- Working memory: Baddeley and Hitch 1974: central executive, phonological loop, visuospatial sketchpad, episodic buffer (2000).
- Levels of processing: Craik and Lockhart 1972: structural < phonetic < semantic.
- Declarative = episodic + semantic (Tulving 1972); non-declarative = procedural, priming, conditioning.
- Skills: cerebellum and basal ganglia; emotion: amygdala; working memory: prefrontal cortex.

2 Measuring memory, forgetting and mnemonics

Memory is measured directly (recall, recognition) or indirectly (relearning savings, priming), and by how faithfully a person reconstructs material; we forget because traces decay, are displaced or interfered with, cannot be retrieved without the right cue, or are pushed away for emotional reasons; and mnemonics fight forgetting with images (loci, keyword, peg-word) and organisation (chunking, first letters). The memory stores and types are in PSY-MM-01; study methods, overlearning and SQ3R are in EDU-LR-01.

Core facts

- **Two kinds of measure:**
 - **Direct (explicit):** the person is asked to remember on purpose: **recall** and **recognition**.
 - **Indirect (implicit):** memory shows up in performance without being asked for: **relearning (savings)** and **priming**.
- **Recall:** reproducing learnt material **without** the material in front of you (fill in the blank, essay).
Forms:
 - **Free recall:** in any order;
 - **Serial recall:** in the original order;
 - **Cued recall / paired associates:** a cue (first word of a pair) is given and the partner must be recalled.
- **Recognition:** identifying learnt items among new ones (MCQ, picking a face in a line-up). Easier and more sensitive than recall.
- **Relearning / savings method: Hermann Ebbinghaus (1885);** learn the material again and measure the time or trials **saved**.
 - **Savings score = (original trials – relearning trials) ÷ original trials × 100.**
 - It shows memory even when nothing can be recalled or recognised; the **most sensitive** measure.
- **Reconstruction:** the person puts items back in their **original order or arrangement**; in a wider sense, remembering is an active **rebuilding** of the past (**F.C. Bartlett, 1932**, the "War of the Ghosts" story; **schemas** fill gaps).
- **Ebbinghaus's forgetting curve:** loss is **fastest soon after learning**, then slows and levels off. He used **nonsense syllables** on **himself**.
- **Theories of forgetting:**
 - **Trace decay:** traces fade with time and disuse (Thorndike's law of disuse).
 - **Displacement:** STM has limited slots; new items push old ones out.
 - **Interference:** other learning gets in the way:
 - **Proactive:** **earlier** learning disrupts recall of **later** learning;
 - **Retroactive:** **later** learning disrupts recall of **earlier** learning.
 - **Retrieval (cue-dependent) failure:** the memory is stored but the right cue is missing (**Tulving**); "tip of the tongue" state.

- **Motivated forgetting / repression: Freud**; painful memories are kept out of awareness.
- Also: **consolidation failure** (injury before a trace is fixed) and **organic causes** (amnesia, Alzheimer's).
- **STM forgetting**: explained mainly by **trace decay and displacement**. **LTM forgetting**: mainly by **interference** and **retrieval failure**.
- **Jenkins and Dallenbach (1924)**: subjects who **slept** after learning forgot less than those who stayed **awake**: support for **interference** over pure decay.
- **Mnemonics**: memory aids that give unfamiliar or abstract material a structure or an image. Two groups (NCERT names keyword and loci under images; the peg-word method is from other textbooks):
 - **Using images: keyword method, method of loci, peg-word method**.
 - **Using organisation: chunking, first-letter technique** (acronyms like VIBGYOR / ROYGBIV, HOMES for the Great Lakes; acrostic sentences).
- **Method of loci**: picture a **familiar place** (rooms of your house, a familiar route) and "place" each item at a spot; walk through it to recall. Credited to the ancient Greek poet **Simonides**.
- **Keyword method**: for a new foreign word, find an English word that **sounds like** it and form an image linking the two (for learning vocabulary).
- **Peg-word method**: learn rhyming "pegs" (**one is a bun, two is a shoe, three is a tree...**) and hang each item on its peg with an image.

Explained

1. Measures compared

Method	What the person does	Type	Strength
Recall	produces the item with few or no cues	direct	hardest; shows the least retained
Recognition	picks the item from alternatives	direct	easier; shows more retained
Relearning (savings)	learns again; trials saved are counted	indirect	most sensitive
Reconstruction	rebuilds order or content	direct	shows distortion by schemas

A student may fail to recall a definition (recall), still pick it in an MCQ (recognition), and relearn it in half the time a month later (savings). All three show some memory.

2. A savings example. A list took 20 trials to learn. A week later it took 8 trials to relearn. Savings = $(20 - 8) \div 20 \times 100 = 60\%$.

3. Recognition and its errors. In recognition tests a person can say "yes" to a new item (**false alarm**) or "no" to an old one (miss). Eyewitness line-ups are recognition tasks, which is why false identifications happen.

4. Reconstruction and eyewitness memory. Bartlett's British students retold a Native American folk tale ("The War of the Ghosts"); with each retelling it became shorter, more familiar and fitted their culture.

Elizabeth Loftus and Palmer (1974): people who heard the word "smashed" instead of "hit" estimated

higher car speeds and later "remembered" broken glass that was not there (**misinformation effect**). For a probation officer, this matters: a child's or witness's account can change with leading questions.

5. Theories of forgetting compared

Theory	Cause	Best explains	Key name
Trace decay	fading with time and disuse	STM loss, old unused facts	Thorndike (disuse)
Displacement	new items push out old in STM	losing a number when interrupted	Waugh and Norman
Interference	other learning competes	similar material learnt close together	Jenkins and Dallenbach
Retrieval failure	cue missing	tip of the tongue	Tulving
Motivated forgetting	emotional defence	traumatic events	Freud

6. Proactive vs retroactive interference: the test. Ask which memory is being lost. If the material learnt **before** spoils it, it is **proactive** (acts forward). If the material learnt **after** spoils it, it is **retroactive** (acts backward).

- You keep writing last year's date in January: old habit blocks new → **proactive**.
- After learning a new phone number you cannot remember the old one → **retroactive**.

Interference is greatest when the two sets of material are **similar**.

7. Cue-dependent forgetting and its forms

- **Encoding specificity** (Tulving): recall is best when the cues at retrieval **match** those at encoding.
- **Context-dependent memory**: divers who learnt words underwater recalled them better underwater (Godden and Baddeley, 1975).
- **State-dependent memory**: recall is better in the same bodily or emotional state as at learning.
- **Tip-of-the-tongue (TOT) state** (Brown and McNeill, 1966): you know the first letter or number of syllables but not the word.

8. Mnemonics: the two groups (images and organisation)

Group	Method	How it works	Example
Images	Method of loci	items placed along a familiar place or route	shopping list placed in rooms of your house
Images	Keyword	sound-alike English word + linking image	learning a Telugu or French word
Images	Peg-word	rhyme pegs + image	"one is a bun": a bun holding the first item
Organisation	Chunking	group items into meaningful units	9849 123 456 as three chunks
Organisation	First-letter	initials form a word or sentence	VIBGYOR, HOMES

Mnemonics help most with **unfamiliar, abstract or list-type** material. Understanding the material, **deep (semantic) processing, distributed practice, overlearning** and **self-testing** remain the main ways to improve memory (see EDU-LR-01).

9. Confusable pairs

Pair	First one	Second one
Recall vs recognition	produce without options (harder)	choose among options (easier)
Relearning vs reconstruction	trials saved on learning again	rebuilding order or content
Direct vs indirect measure	recall, recognition (explicit)	savings, priming (implicit)
Decay vs displacement	fading over time	pushed out by new items
Decay vs interference	time alone	other learning competes
Proactive vs retroactive	old blocks new	new blocks old
Retrieval failure vs repression	cue missing	emotional defence (Freud)
Method of loci vs peg-word	familiar places	rhyming number pegs
Keyword vs peg-word	sound-alike word for vocabulary	fixed list of rhyme pegs
Chunking vs first-letter	group items into units	initials into a word
Imagery vs organisation mnemonics	loci, keyword, peg-word	chunking, first-letter

Common traps

✗ "Recognition is harder than recall." ✓ **Recall** is harder; recognition is easier.

✗ "The savings method is a direct method." ✓ Savings (relearning) is an **indirect** measure; recall and recognition are **direct**.

✗ "Bartlett invented the savings method." ✓ Savings = **Ebbinghaus (1885)**; reconstruction and schemas = **Bartlett (1932)**.

✗ "Proactive interference: new learning blocks old." ✓ That is **retroactive**; **proactive** = **old** blocks **new**.

✗ "STM forgetting is best explained by repression." ✓ STM forgetting = **trace decay and displacement**.

✗ "Jenkins and Dallenbach supported decay." ✓ Their sleep study supported **interference**.

✗ "Tip-of-the-tongue shows the memory is lost." ✓ It shows **retrieval failure**: the memory is stored.

✗ "Method of loci uses rhymes." ✓ Loci uses **familiar places**; the **peg-word** method uses rhymes.

✗ "Chunking is an imagery mnemonic." ✓ Chunking and first-letter are **organisation** mnemonics; loci, keyword and peg-word use **images**.

✗ "Forgetting is fastest weeks after learning." ✓ It is fastest **soon after** learning, then levels off (Ebbinghaus).

Quick revision

- Direct measures: recall, recognition; indirect: relearning (savings), priming.
- Recall forms: free, serial, cued / paired associates; recognition is easier than recall.
- Savings = $(\text{original} - \text{relearning trials}) \div \text{original} \times 100$; Ebbinghaus 1885, most sensitive.
- Reconstruction: Bartlett 1932, "War of the Ghosts", schemas; Loftus: misinformation.
- Forgetting curve: steep early fall, then levels off.
- STM forgetting: decay and displacement; LTM forgetting: interference and retrieval failure.
- Proactive = old blocks new; retroactive = new blocks old; Jenkins and Dallenbach 1924: sleep reduces interference.
- Retrieval failure: cue-dependent (Tulving), tip of the tongue; repression: Freud.
- Image mnemonics: loci (familiar places), keyword (sound-alike), peg-word (one is a bun).
- Organisation mnemonics: chunking, first-letter (VIBGYOR, HOMES).