Sensory Memory

Definition

Sensory memory is the shortest type of memory in the human memory system. It holds sensory information (sights, sounds, smells, etc.) for a very brief period — typically less than a second to a few seconds — long enough for it to be processed further or dismissed.

Key Characteristics of Sensory Memory

Duration: Extremely brief (milliseconds to a few seconds).

Capacity: Very high, but not consciously accessible.

Function: Acts as a buffer for stimuli received through the five senses.

Attention-Dependent Transfer: Information must be attended to in order to move to short-term memory.

☐ Types of Sensory Memory

1. ☐ Iconic Memory (Visual Sensory Memory)

Modality: Visual

Duration: ~250 milliseconds

Capacity: Very large

Discovered by: George Sperling (1960)

Experiment: Partial-report technique showed people could see more items than they could report due to rapid fading of memory.

Role: Allows continuity in visual experience (e.g., watching a movie frame-by-frame).

2. ☐ Echoic Memory (Auditory Sensory Memory)

Modality: Auditory

Duration: ~3–4 seconds

Capacity: More limited than iconic, but longer duration

Key researcher: Darwin, Turvey, and Crowder (1972)

Function: Enables understanding of spoken language (e.g., processing a full sentence even after a delay).

3. ☐ Haptic Memory (Tactile Sensory Memory)

Modality: Touch

Duration: ~1–2 seconds

Sensory Memory (cont)

Still under-researched, but studies show it plays a role in spatial perception and motor planning.

4. ☐ Gustatory Memory (Taste) and ☐ Olfactory Memory (Smell)

Less well understood

Potentially longer lasting than visual and auditory sensory memory

Important in emotional memory and recognition

☐ Key Concepts Related to Sensory Memory

✅ Pre-Attentive Processing

Occurs in sensory memory

Allows for basic analysis (e.g., shape, pitch, color) before attention is directed.

✅ Masking

Refers to interference with sensory memory

Backward masking in iconic memory — when a visual stimulus interferes with another shortly after.

✅ Modality Effect

The superior recall of the last items in a list when presented auditorily vs. visually

Evidence for longer duration of echoic memory

✅ Change Blindness & Inattentional Blindness

Related phenomena showing limits of attention

Despite availability in sensory memory, unattended stimuli can go unprocessed.

✅ Temporal Integration

Ability to combine sensory input across time (especially in auditory memory)

Helps in recognizing words or phrases from sounds

☐ Sensory Memory in Cognitive Psychology

Buffer Function: Sensory memory acts as a temporary holding zone for raw data, allowing selective attention to process what's relevant.

Temporal Resolution: Sensory memory allows rapid processing of rapidly changing stimuli, helping the system detect motion, changes, or transitions.

Sensory Memory (cont)

Interface for Perception and Attention: It's a precursor to perceptual processing, influencing what information reaches short-term and long-term memory.

Iconic and Echoic Memory in Cognition:

Iconic memory supports visual search and scene continuity.

Echoic memory is essential for language processing and auditory scene analysis (e.g., distinguishing a voice in a noisy room).

Key Brain Areas for Sensory Memory

Sensory Type	Brain Area	Description
Iconic (Visual)	Primary Visual Cortex (V1), extrastriate areas	Responsible for brief visual traces; neural activity can persist briefly even after stimulus offset.
Echoic (Auditory)	Primary Auditory Cortex (A1), superior temporal gyrus	Stores auditory traces; important for speech recognition and attention to sounds.
Haptic (Touch)	Somatosensory Cortex	Encodes short-term tactile information for spatial mapping and feedback.

Important Experiments on Sensory Memory

Researcher(s)	Aim	Procedure	Findings/Conclusions

Important Experiments on Sensory Memory (cont)

George Sperling (1960)	To test the capacity and duration of iconic memory	Participants were shown a 3×4 grid of letters for 50 ms. In the whole report condition, they were asked to recall all letters. In the partial report condition, they were cued (e.g., with a tone) to recall a specific row immediately after display.	Participants could recall only 4 letters in the whole report, but nearly all letters from the cued row in the partial report. This suggested iconic memory has large capacity but brief duration (250–500 ms).
Darwin, Turvey, & Crowder (1972)	To examine the characteristics of echoic memory (auditory)	Used a three-eared man setup: presented 3 streams of spoken letters simultaneously from different spatial locations (left, right, center), each with a pitch cue. After presentation, a tone cued participants to recall from one stream.	Performance in the partial report condition was better than in whole report, similar to Sperling's findings, but the auditory trace lasted 2–4 seconds, indicating longer echoic memory than iconic.

Important Experiments on Sensory Memory (cont)

Crowder & Morton (1969) – The "Pre-categorical Acoustic Store" (PAS)	To test whether echoic memory stores physical (sensory) characteristics rather than meaning	Participants heard lists of spoken digits and were asked to recall them. The recency effect was stronger when digits were spoken vs. read silently.	Echoic memory is precategorical and stores acoustic properties. Stronger recency for auditory lists supported the existence of a short-lived auditory store.
Neisser (1967)	To conceptualize sensory memory, especially iconic memory	Theorized based on earlier experiments, including Sperling’s	Coined the term "iconic memory" and described it as a brief, visual sensory store that decays quickly and is separate from visual short-term memory.
Averbach & Coriell (1961)	To further investigate visual persistence and interference in iconic memory	Presented arrays of letters and used a visual cue (a bar or circle) instead of a tone to indicate which letter to report. Cues were shown at different time intervals.	Performance dropped when a circle was used, due to masking effects. Showed that interference can disrupt iconic memory before decay alone.

Important Experiments on Sensory Memory (cont)

Phillips (1974)	To test the role of visual complexity and matching in iconic memory	Presented participants with complex visual patterns, followed by either the same or a different pattern after a brief delay. Participants had to say whether they matched.	Accuracy dropped rapidly after ~300 ms, supporting the idea of a short-lived high-fidelity visual store.
Treisman (1964) – Attenuation theory	To investigate whether unattended information is completely lost in auditory sensory memory	Used a dichotic listening task where a meaningful message switched from one ear to the other midstream. Participants were told to attend to only one ear.	Many participants followed the message to the other ear, suggesting that unattended auditory information is not entirely filtered out — it is attenuated, not erased.
Sams et al. (1993)	To measure the duration of auditory sensory memory with neurophysiological methods	Used MEG (magnetoencephalography) to detect MMN (Mismatch Negativity) responses to deviant auditory stimuli after different time delays.	MMN was observed up to 10 seconds after standard tone presentation. Showed that echoic memory traces can persist neurologically longer than previously thought.

Short Term Memory

Short-Term Memory (STM): A limited-capacity system that temporarily holds information for brief periods (about 15–30 seconds) without rehearsal.

Capacity: Classically believed to be 7 ± 2 items (Miller, 1956), though later research suggests it may be closer to 4–5 items.

Short Term Memory (cont)

Duration: Typically 15–30 seconds without rehearsal.

Encoding: Primarily acoustic/phonological, though some visual and semantic encoding can occur.

Forgetting: Occurs due to decay (time-based loss) and interference (mainly proactive and retroactive).

Rehearsal: Repetition that helps maintain items in STM and facilitates transfer to Long-Term Memory (LTM).

☐ Characteristics of Short-Term Memory (STM)

1. Limited Capacity

STM can hold about 7 ± 2 items (Miller, 1956).

Later research (e.g., Cowan, 2001) suggests the true capacity may be closer to 4–5 items.

Chunking (grouping items into meaningful units) can increase capacity.

2. Short Duration

Without rehearsal, STM retains information for only 15–30 seconds.

After that, information decays or is replaced.

3. Acoustic Encoding (Primarily)

STM encodes information mostly by sound, even if it’s seen (e.g., letters visually shown may be remembered by their sound).

Evidence: Conrad (1964) found people confuse acoustically similar letters (e.g., B, D, P) more than visually similar ones.

4. Vulnerability to Interference

STM is very sensitive to both proactive and retroactive interference.

New info can displace old info (Waugh & Norman, 1965).

Rehearsal Maintains Information

Maintenance rehearsal helps retain info in STM.

Without rehearsal, information is quickly forgotten (Peterson & Peterson, 1959).

Serial Position Effect

STM contributes to the recency effect (better recall of last items in a list).

Shows the importance of temporal context in recall.

7. Information Transfer to LTM

Short Term Memory (cont)

Rehearsal, especially elaborative rehearsal, helps encode information into Long-Term Memory.

STM acts as a gateway to LTM in many memory models.

8. Conscious Awareness

STM (or working memory) holds information we are consciously aware of and currently thinking about.

Used for active processing, decision-making, and problem-solving.

9. Active vs Passive Debate

Classical view: STM is a passive storage system (e.g., Atkinson-Shiffrin model).

Modern view: STM is part of Working Memory, an active system involving manipulation (Baddeley & Hitch, 1974).

10. Brain Basis

Associated mainly with the prefrontal cortex, especially for manipulation and attention.

Does not depend heavily on the hippocampus, unlike long-term memory.

Short-Term vs Working Memory

STM	Working Memory
Temporary storage only	Storage + manipulation of info
Passive system	Active processing system
Associated with Atkinson-Shiffrin model	Associated with Baddeley & Hitch model

STM in Neuroscience

Aspect	Detail
Brain Regions	- Prefrontal Cortex (especially dorsolateral): Temporary maintenance and manipulation of information. - Hippocampus: Less directly involved in STM, more for LTM encoding. - Parietal Cortex: Linked to storage aspects.

STM in Neuroscience (cont)

Neural Basis	- Sustained firing of neurons in the prefrontal cortex represents active STM. - Functional connectivity between cortical and subcortical areas.
Neurotransmitters	- Dopamine and norepinephrine are critical for attention and working memory functions.
Neuroimaging Techniques	- fMRI and EEG used to examine load-dependent activation in STM tasks. - TMS studies show causal role of PFC in STM manipulation.

Key Experiments

Researcher(s)	Aim	Procedure	Findings/Conclusions
Peterson & Peterson (1959)	To study the duration of STM	Presented participants with 3-letter trigrams (e.g., "KLP") and had them count backward by 3s to prevent rehearsal.	Recall dropped drastically after 18–20 seconds → STM has a brief duration.
Miller (1956)	To examine STM capacity	Review of memory tasks using digits, words, tones.	STM holds about 7 ± 2 items. Introduced the idea of chunking.
Baddeley (1966)	To investigate STM encoding	Presented lists of acoustically similar and dissimilar words for immediate recall.	STM primarily encodes acoustically – worse recall for similar-sounding words.

Key Experiments (cont)

Wickens et al. (1976) – Release from Proactive Interference	To show that STM can use semantic encoding	Participants remembered word lists from the same or different categories.	Performance improved when category changed → STM can encode semantically under certain conditions.
Conrad (1964)	To test encoding in STM	Presented letters visually and asked for recall.	Errors were more likely to be acoustically similar (e.g., "P" mistaken for "B") → acoustic coding dominates.

Long Term Memory

Long-Term Memory (LTM) refers to the system responsible for storing information over extended periods—from minutes to a lifetime. It differs from STM in terms of capacity, duration, and encoding.

☐ Duration: Virtually unlimited (can last a lifetime)

☐ Capacity: Vast, possibly unlimited

☐ Encoding: Primarily semantic, but also includes visual, auditory, and olfactory encoding

Types of Long Term Memory

Category	Subtypes	Details
Explicit (Declarative)	- Episodic - Semantic	Episodic: Personal experiences/events (e.g., your last birthday) Semantic: Factual/general knowledge (e.g., Paris is the capital of France)

Types of Long Term Memory (cont)

Implicit (Non-Declarative)	-Procedural - Priming - Conditioning	Procedural: How to do things (e.g., riding a bike) Priming: Earlier exposure influences later response Conditioning: Classical and operant responses stored over time

LTM (more info)

1. Autobiographical Memory

Mix of episodic and semantic memory.
Refers to memories of personal life events.
Related to self-concept and identity.
Brain areas: medial prefrontal cortex, hippocampus, and amygdala.

2. Flashbulb Memory

Vivid, detailed memories of emotionally charged events (e.g., natural disasters, 9/11).
Research by Brown & Kulik (1977).
Often high in confidence but not always accurate.
Involves the amygdala and stress hormones (e.g., adrenaline).

3. Prospective Memory

Remembering to perform actions in the future (e.g., taking medication).
Involves executive functioning and prefrontal cortex.
Types: event-based (cue-triggered) and time-based.

4. Schema Theory and Memory

Schemas are mental frameworks that influence how we encode, store, and retrieve memories.
Bartlett (1932): "War of the Ghosts" study—people reconstructed stories based on cultural expectations.
Memory is reconstructive, not reproductive.

5. Encoding Specificity Principle (Tulving & Thomson, 1973)

Context and state during encoding affect recall.
If you learn something while sad, you're more likely to recall it while sad (state-dependent memory).

6. Memory Consolidation and Sleep

Consolidation = stabilizing memory traces.
Occurs during REM and slow-wave sleep.
Hippocampus replays recent events to integrate them into cortex.

LTM (more info) (cont)

7. Reconsolidation and Memory Modification

Every time a memory is retrieved, it becomes temporarily unstable and open to modification or distortion.
Important in therapy for PTSD, where traumatic memories can be safely altered.

8. Dual-Process Theories of Recognition

Recollection: Conscious retrieval of contextual details (episodic).
Familiarity: Feeling of knowing without full details (semantic).
Supported by studies using Remember/Know paradigms.

9. Neurotransmitters Involved in LTM

Glutamate: Key for LTP and synaptic plasticity
Acetylcholine: Important in attention and memory encoding (especially in the hippocampus)
Dopamine: Enhances memory via reward-based learning
Cortisol: High levels impair memory, especially retrieval

10. LTM Across the Lifespan

Infantile amnesia: Lack of episodic memories from early childhood (before ~3 years).
Reminiscence bump: People recall more memories from ages 10–30, especially meaningful life events.
Aging: Semantic memory often preserved; episodic memory and working memory decline.

Neuroscience of LTM

Memory Type	Brain Area(s) Involved
Episodic Memory	Hippocampus, prefrontal cortex
Semantic Memory	Temporal lobe, inferior parietal lobe
Procedural Memory	Basal ganglia, cerebellum, motor cortex
Emotional Memory	Amygdala (especially fear conditioning)

Key Experiments (LTM)

Researcher(s)	Aim	Procedure	Findings/Conclusions
Ebbinghaus (1885)	Examine forgetting	Memorized nonsense syllables, tested recall over time	Introduced the Forgetting Curve and Spacing Effect

Key Experiments (LTM) (cont)

Craik & Tulving (1975)	Study depth of processing	Participants processed words at shallow, intermediate, or deep levels	Deeper processing led to better recall
Tulving (1983)	Examine episodic retrieval	Used neuroimaging to study brain activation during memory tasks	Found different areas active for episodic vs. semantic memory
Godden & Baddeley (1975)	Context-dependent memory	Scuba divers learned words on land or underwater and recalled them in same/different context	Recall was better in matching contexts
Milner (1966) – HM case study	Understand role of hippocampus	Studied patient HM who had hippocampus removed	Showed hippocampus crucial for forming new declarative memories, but procedural memory remained intact

Atkinson-Shiffrin Model of Memory (1968)

The Atkinson-Shiffrin model, proposed in 1968, is one of the earliest and most influential models of memory. It describes memory as a linear process involving three separate stores:

☐ Sensory Register → Short-Term Memory → Long-Term Memory

It emphasizes encoding, storage, and retrieval as the core processes of memory.

The Three Memory Stores

Sensory Register
<1–2 seconds
Very large Raw/unprocessed (modality-specific: visual, auditory, etc.)
Rapid decay

Short-Term Memory (STM)
~15–30 seconds
7 ± 2 items (Miller, 1956) Acoustic (mainly)
Displacement & decay

Long-Term Memory (LTM)
Potentially lifetime
Unlimited
Primarily semantic
Retrieval failure, interference

Key Processes in the Model

Attention
Focusing on specific sensory input
Moves info from sensory to STM

Rehearsal
Repeating information mentally or aloud
Transfers info from STM to LTM

Encoding
Transforming input for storage
STM: acoustic; LTM: semantic

Retrieval
Accessing stored information
From LTM back to STM for use

Forgetting
Loss of stored info
Each store has different causes (e.g., decay, interference)

Strengths of the Model

✅ Clear structure—easy to test experimentally

✅ First to distinguish memory types systematically

✅ Explains serial position effect

✅ Supported by neuropsychological evidence (e.g., patient HM)

Criticisms & Limitations

✖ Oversimplified – memory is not purely linear

✖ Too focused on rehearsal – not the only route to LTM

✖ Doesn’t explain implicit memory or procedural learning

✖ Lacks explanation of interaction between STM and LTM (e.g., chunking uses LTM knowledge in STM)

Baddeley & Hitch’s Working Memory Model (1974)

1. Why It Was Proposed

To replace the oversimplified Short-Term Memory (STM) store in Atkinson & Shiffrin's model.
Emphasized that memory is not a single passive store, but an active, multi-component system for holding and manipulating information.

Core Components of the Model

a. Central Executive

☐ Main control system
Directs attention, allocates tasks to subsystems.
Has limited capacity, doesn’t store info itself.
Involved in planning, problem-solving, decision-making.

b. Phonological Loop

Deals with verbal/auditory information.
Two sub-parts:
Phonological Store ("inner ear") – holds spoken words briefly.
Articulatory Control Process ("inner voice") – allows rehearsal.
Crucial for language processing and learning.

c. Visuo-Spatial Sketchpad

Handles visual and spatial information.
Called the "inner eye".
Involved in navigation, mental imagery, and visual memory.
Later split into:
Visual cache (stores form/color)
Inner scribe (records spatial/movement info)

d. Episodic Buffer (added in 2000)

Integrates info from PL, VSS, and LTM into coherent episodes.
Has limited capacity.
Useful in working with integrated multi-modal information (e.g., stories).

Supporting Research & Evidence

☐ Dual-Task Studies (Baddeley & Hitch, 1974) Participants performed two tasks at once:
One verbal (e.g., repeating numbers)
One reasoning (e.g., true/false questions)
Result: Could do both, but slower → suggests separate systems (not a single STM).
☐ Word Length Effect (Baddeley et al., 1975) Short words are recalled better than long words.
Supports idea of a time-limited phonological loop.
☐ Logie (1995) Gave evidence for separate visual and spatial stores in the visuo-spatial sketchpad.
☐♂☐ KF Case Study (Shallice & Warrington, 1970) Brain damage: poor verbal STM, good visual memory.
Supports the existence of different STM components.

Strengths of the Model

Baddeley & Hitch’s Working Memory Model (1974) (cont)

Explains multi-tasking.
Evidence from brain imaging (e.g., different areas for verbal/visual tasks).
More realistic than the MSM – reflects cognitive flexibility.
Accounts for active processing (not just storage).

Weaknesses of the Model

Central Executive is vague – lacks detailed explanation.
Little is known about how subsystems interact.
Mostly tested in lab settings – ecological validity?
May underestimate the role of LTM in working memory tasks.

Craik and Lockhart’s Levels of Processing Model

Overview and Key Concepts

Craik and Lockhart challenged the multi-store model of memory.
Proposed that memory is a by-product of the depth of processing, not of distinct stores.
Emphasis is on how information is processed, not where it is stored.
Deeper processing = better long-term retention.
Memory durability depends on levels of analysis (not repetition alone).

☐ Levels of Processing

Shallow Processing
Focuses on surface features (e.g., structure, sound).
Includes: visual (what it looks like) and phonemic (how it sounds) encoding.
Results in weak, short-lived memory traces.
Intermediate Processing
Involves some analysis, such as recognizing a word's sound or rhyme.
Better than shallow, but still not optimal for long-term retention.
Deep (Semantic) Processing
Focuses on meaning, context, or relating new info to existing knowledge.
Encourages elaboration, association, and comprehension.
Produces stronger, more durable memory traces.

☐ Supporting Experiments

Craik & Tulving (1975)
Participants were asked questions about words requiring different depths of processing:
Shallow (Is the word in capital letters?)
Intermediate (Does it rhyme with ‘cat’?)
Deep (Does it fit in the sentence: “He met a ___ on the street”?)
Findings: Words processed deeply were recalled more accurately.
Conclusion: Depth of processing has a direct effect on memory.

✓☐ Strengths of the Model

Explains why elaborative rehearsal is more effective than maintenance rehearsal.
Emphasizes cognitive processes over storage structures.
Supported by a range of experimental evidence.
Influential in educational practices – encouraged meaningful learning.

Craik and Lockhart’s Levels of Processing Model (cont)

☐ Limitations of the Model

No clear definition of what counts as “depth” – it's vague and circular.

Difficult to objectively measure levels of processing.

May underestimate the role of memory structures (e.g., STM vs. LTM distinction).

Doesn’t explain why deep processing doesn’t always lead to better recall.

☐ Applications

Learning techniques: Encourages elaboration, summarization, and connecting to prior knowledge.

Useful in designing educational content for better retention.

Applied in understanding encoding processes in memory disorders.

Tulving’s LTM Model

☐1. Introduction

Proposed by Endel Tulving in 1972 and revised in 1985.

Argued that LTM is not a single store, but consists of distinct subsystems.

First to clearly separate Episodic and Semantic memory; later added Procedural and Priming.

☐ 2. Main Components of Long-Term Memory

a. Episodic Memory

Stores personal experiences tied to a specific time and place.

Example: Remembering your last birthday.

Context-dependent and involves mental time travel.

Neural basis: Hippocampus, medial temporal lobe.

b. Semantic Memory

Stores general knowledge, facts, concepts, and meanings.

Example: Knowing that Paris is the capital of France.

Not linked to personal experience or time.

Neural basis: Temporal lobe, especially left hemisphere structures.

c. Procedural Memory (added later)

Memory for skills and actions; often unconscious.

Example: Riding a bicycle, typing on a keyboard.

Neural basis: Cerebellum, motor cortex, basal ganglia.

d. Priming (also called Perceptual Representation System)

Implicit memory where exposure to one stimulus influences response to another.

Example: More likely to recognize a word you've seen recently.

Neural basis: Neocortex, visual association areas.

☐ 3. Supporting Evidence

KC (Tulving, 1989): Brain injury left him with no episodic memory but intact semantic memory.

Clive Wearing: Severe amnesia; lost episodic memory but retained procedural skills (e.g., piano playing).

Neuroimaging: PET and fMRI scans show different brain regions activate for episodic vs. semantic tasks.

Tulving's LTM Model (cont)

✓☐ 4. Strengths of the Model

Explains different types of LTM observed in brain-damaged patients.

Supported by neuropsychological and brain imaging evidence.

Provides a more realistic, detailed view of memory compared to older models.

Accounts for both conscious (explicit) and unconscious (implicit) memory.

✕ 5. Limitations of the Model

Overlap between types of LTM (e.g., semantic memories often have episodic origins).

Difficult to clearly separate memory systems experimentally.

Not all memories fit neatly into just one category.

☐ 6. Applications

Understanding amnesia, Alzheimer's, and other memory disorders.

Applied in education, as episodic memory can help encode semantic content.

Used in therapeutic approaches for trauma and skill training.

Parallel Distribution Processing Model

Introduction and Overview

Developed in the 1980s by researchers like Rumelhart, McClelland, and the PDP Group.

Also known as Neural Network Model or PDP (Parallel Distributed Processing) Model.

Inspired by how neurons function in the brain.

Emphasizes distributed, parallel processing of information across a network.

Key Concepts

Units: Basic processing elements that simulate neurons.

Connections: Like synapses between neurons; can be strong, weak, excitatory, or inhibitory.

Nodes: Represent concepts, features, or word meanings.

Activation: When a node or unit is "turned on" by incoming information.

Spreading Activation: When activation spreads across the network to related nodes.

Weighting: Each connection has a "weight" which affects how signals are processed.

Learning: Occurs through adjustment of connection weights (Hebbian learning principles: "cells that fire together, wire together").

☐ How Memory Works in This Model

Memory is not stored in one place, but is distributed across a network.

Each memory is represented by a pattern of activation across multiple nodes.

Retrieval is reconstructive – patterns of activation are recreated rather than replayed exactly.

More overlapping patterns = more associations = easier retrieval.

Forgetting occurs when activation patterns become weak or disrupted.

☐ Supporting Evidence and Applications

Parallel Distribution Processing Model (cont)

Simulations show the model can learn language, recognize patterns, and even generalize to new inputs.

Explains phenomena like tip-of-the-tongue, semantic priming, and graceful degradation (partial memory loss).

Has influenced fields like AI, cognitive neuroscience, and psycholinguistics.

✔☐ Strengths of the Model

Biologically inspired – mirrors how the brain likely processes information.

Explains how learning and memory are adaptive and flexible.

Can account for partial recall, generalization, and error patterns in memory.

Describes how we process meaning, not just store information.

☐ Limitations of the Model

Often too abstract or complex to fully map onto actual brain activity.

Difficult to test and falsify experimentally.

Sometimes fails to distinguish between different memory types (e.g., episodic vs. semantic).

May oversimplify cognitive functions by focusing only on activation patterns.

Encoding in Memory

☐ What is Encoding?

Encoding refers to the initial process of transforming sensory input into a form that can be stored in the brain.

It is the first stage of the memory process (Encoding → Storage → Retrieval).

Encoding determines the strength, durability, and accessibility of memory traces.

It is not passive—how we encode influences how well we remember.

☐ Types of Encoding

Visual Encoding: Based on the appearance of stimuli (e.g., images, shapes, colors).

Acoustic Encoding: Based on the sound of information (e.g., rhymes, rhythm, verbal repetition).

Semantic Encoding: Based on meaning; involves elaboration and association with existing knowledge.

Tactile Encoding: Based on physical sensations (e.g., texture).

Olfactory and Gustatory Encoding: Rare, but potent when linked with emotional or episodic memories.

☐ Levels of Processing Theory (Craik & Lockhart, 1972)

Memory is influenced more by depth of processing than by separate memory stores.

Shallow processing: Structural and phonemic processing leads to weak memory traces.

Deep processing: Semantic encoding leads to stronger and more durable memory.

Depth is enhanced by elaboration, distinctiveness, and meaning-making.

Encoding in Memory (cont)

☐ Key Experiments in Encoding

Craik & Tulving (1975): Found that words processed semantically were recalled more than those processed visually or acoustically.

Hyde & Jenkins (1969): Participants who judged pleasantness of words (deep processing) recalled more than those who counted letters (shallow).

Bower et al. (1969): Hierarchical organization during encoding improves recall.

Bransford & Johnson (1972): Context helps encoding; participants recalled more when given meaningful context.

☐ Factors Influencing Encoding

Attention: Essential for effective encoding—without attention, information decays rapidly.

Elaboration: Linking new information to prior knowledge improves encoding.

Distinctiveness: Unusual or unique items are encoded more deeply.

Rehearsal Type: Elaborative rehearsal (meaning-based) is superior to maintenance rehearsal (rote repetition).

Organizational Strategies: Chunking, imagery, and mnemonics enhance encoding efficiency.

☐ Neuroscience of Encoding

Encoding is supported by the hippocampus, prefrontal cortex, and medial temporal lobes.

Hippocampus plays a critical role in consolidating encoded information into long-term memory.

Prefrontal cortex assists in attentional control and selecting encoding strategies.

Neuroimaging (fMRI, PET) shows increased activity in the left hemisphere for verbal encoding, and right for visual encoding.

Neurotransmitters like acetylcholine and glutamate are involved in encoding processes.

☐ Encoding Specificity Principle (Tulving & Thomson, 1973)

Recall is most effective when retrieval conditions match encoding conditions.

Context-dependent memory: Environmental cues present during encoding aid retrieval.

State-dependent memory: Internal states (mood, drug-induced states) influence recall.

Mood-congruent memory: We recall information consistent with our current mood.

✔☐ Practical Applications of Encoding Research

Educational psychology: Encouraging meaningful learning and elaboration improves academic performance.

Memory rehabilitation: Techniques like chunking, visualization, and association aid memory-impaired individuals.

Cognitive therapy: Re-encoding traumatic memories in safer, new emotional contexts (e.g., EMDR).

☐ Encoding Failures

Encoding in Memory (cont)

Encoding failure occurs when information never enters long-term memory due to lack of attention or processing.

Common in divided attention tasks or passive learning environments.

Forgetting is often due to ineffective encoding, not memory decay.

Retrieval Processes

☐ What is Retrieval?

Retrieval refers to the process of accessing stored information from long-term memory.

It is the final stage in the memory process, after encoding and storage.

Retrieval is influenced by how the information was encoded, the type of memory, and retrieval conditions.

Retrieval can be intentional (effortful) or spontaneous (automatic).

☐ Retrieval Cues

Retrieval cues are stimuli or triggers that assist in accessing stored memories.

They can be external (environmental, verbal hints) or internal (emotional state, mental associations).

Effective cues often involve associative links formed during encoding.

Cue overload principle: A cue is less effective if it is linked to many items.

Distinctive cues enhance retrieval by reducing interference.

☐ Context-Dependent Retrieval

Memory is better retrieved in the same context in which it was encoded.

This includes physical surroundings, people, smells, lighting, and ambient sounds.

Classic study: Godden & Baddeley (1975) found divers recalled more words when encoding and retrieval occurred underwater or both on land.

Context acts as a retrieval scaffold, facilitating access to stored traces.

☐ State-Dependent Retrieval

Retrieval improves when a person’s internal physiological or psychological state matches their state during encoding.

Includes effects of mood, arousal, drugs, fatigue, or stress.

Common example: people intoxicated at encoding may recall better when intoxicated again.

Supports the idea that internal states function like retrieval cues.

☐ Mood-Congruent Memory

Retrieval Processes (cont)

We are more likely to recall memories that match our current emotional state.

This is not about encoding state, but about bias in retrieval content.

Depressed individuals, for example, tend to recall more negative life events.

☐ Recall vs. Recognition

Recall: Retrieval without direct cues. Requires reconstructing information.

Examples: Essay tests, free recall tasks.

Types: Free recall, serial recall, and cued recall.

Typically more demanding than recognition.

Recognition: Identifying previously learned information when it is presented again.

Examples: Multiple choice questions, face recognition.

Less effortful—relies on familiarity and retrieval matching.

Recognition is often more accurate than recall due to cue support.

☐ Key Experiments and Theories in Retrieval

Tulving’s Encoding Specificity Principle: Retrieval is most effective when cues match the encoding context.

Godden & Baddeley (1975): Environmental context effects in divers.

Eich (1975): Demonstrated state-dependent learning using mood induction.

Loftus (1975): Misinformation effect—shows how retrieval can be distorted by post-event information.

Nelson (1971): Showed that forgotten items can be retrieved when original cues are reinstated.

☐ Neurocognitive Aspects of Retrieval

Hippocampus: Essential for relational memory retrieval and reactivating stored memory patterns.

Prefrontal cortex: Involved in retrieval effort, monitoring, and decision-making during recall.

Parietal lobes: Associated with subjective experience of remembering, like familiarity.

Retrieval involves pattern completion: reinstating parts of the stored trace using cues.

☐ Retrieval Practice (Testing Effect)

Repeated retrieval strengthens memory more than passive review.

Roediger & Karpicke (2006): Testing enhances long-term retention better than re-studying.

Retrieval promotes reconsolidation and deepens encoding pathways.

⚠☐ Retrieval Failures and Blocking

Retrieval Processes (cont)

Retrieval failures are not always due to forgetting—can be caused by:
Interference (retroactive/proactive),
Cue-dependent forgetting,
Decay of the memory trace,
Inhibition or motivated forgetting (e.g., repression).
Tip-of-the-Tongue (TOT) phenomenon: Partial retrieval; activation without full access.
Blocking: Interference from competing memories (e.g., similar names).

Forgetting

What is Forgetting?

orgetting refers to the inability to retrieve information previously encoded and stored in memory.
It may occur due to weak encoding, interrupted consolidation, trace decay, retrieval failure, motivated forgetting, or errors in memory processing.
It’s not always dysfunctional—it helps cognitive efficiency by allowing us to filter irrelevant or outdated information.

The Seven Types of Forgetting (Schacter’s “Seven Sins of Memory”)

a. Transience
Forgetting that occurs with the passage of time.
Memory traces become weaker or degrade if not recalled or rehearsed.
Closely related to trace decay theory.

b. Absent-Mindedness
Forgetting due to a lack of attention or shallow encoding.
Often results from distraction or divided attention at the time of encoding.
Example: Forgetting where you placed your keys.

c. Blocking
Temporary inability to access stored information.
Often manifests as the Tip-of-the-Tongue (TOT) phenomenon.
Memory is available but inaccessible at that moment.

d. Misattribution
Assigning a memory to the wrong source (e.g., thinking someone else told you something).
Can contribute to false memories and distorted recall.

e. Suggestibility
Incorporation of misleading information from external sources into personal recollections.
Often observed in eyewitness testimony and memory distortion due to leading questions.

f. Bias
Retrospective distortions caused by current beliefs, emotions, or knowledge.
People reshape past events to better fit their present view of themselves or the world.

g. Persistence
Unwanted memories that intrude into consciousness.
Often emotionally charged, and seen in PTSD or rumination.
Contrary to typical forgetting – it’s the inability to forget.

Trace Decay Theory

Forgetting (cont)

Suggests that memory traces fade over time if not actively rehearsed.
Based on the physiological decay of memory traces in the brain.
Applies best to sensory memory and short-term memory.
Peterson & Peterson (1959): Demonstrated rapid STM forgetting when rehearsal was blocked.

Interference Theory

Proposes that conflicting information disrupts memory retrieval.
Two key types:

Proactive Interference (PI)
Older memories interfere with the learning or recall of new material.
Example: Using your old PIN when trying to recall a new one.

Retroactive Interference (RI)
New information interferes with the retrieval of older memories.
Example: Forgetting your old address after memorizing your current one.
Underwood (1957): Found evidence for PI in list-learning studies.
McGeoch & McDonald (1931): RI is stronger when materials are similar.

Motivated Forgetting (Freudian Theory)

Originates from Freud’s psychodynamic theory.
Proposes that people forget emotionally disturbing or threatening memories to protect the ego.
Two main forms:
Repression: Unconscious blocking of distressing memories.
Suppression: Conscious, intentional effort to avoid remembering.
Anderson & Green (2001): Experimental support via Think/No-Think paradigm.

Retrieval Failure (Cue-Dependent Forgetting)

Memory is stored but cannot be accessed due to a lack of proper retrieval cues.
Explained by Encoding Specificity Principle (Tulving): retrieval is most effective when context matches encoding.
Examples: Forgetting a name until reminded by a mutual friend.

Additional Concepts Related to Forgetting

Tip-of-the-Tongue (TOT) Phenomenon
Partial retrieval failure – the feeling of knowing something but being unable to retrieve it.
b. Consolidation Failure
Forgetting due to interruption or failure during memory consolidation, often due to trauma or interference.
c. Directed Forgetting
Intentional forgetting due to instructions or cognitive control.
Studied using item-method and list-method paradigms.
d. Organic Causes of Forgetting
Brain damage, neurodegenerative diseases (e.g., Alzheimer’s, Korsakoff’s syndrome), and trauma can impair memory.
These typically affect episodic and semantic memory, but procedural memory often remains intact.

Neurobiological Aspects of Forgetting

Forgetting (cont)

Hippocampus: Crucial for memory consolidation; damage results in anterograde or retrograde amnesia.

Prefrontal Cortex: Involved in retrieval, inhibition of unwanted memories, and cognitive control.

Forgetting may also result from synaptic pruning and long-term depression (LTD) – reduction in synaptic strength.

Neurotransmitters like glutamate, GABA, and acetylcholine influence memory encoding and stability.