# IST605: Human Information Processing — Memory I Summary

## Document Outline



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## 1. Introduction

### Uses of Memory

Memory serves multiple functions beyond simple fact retrieval:

1. **Store and retrieve facts**
    - Direct retrieval: "What is the capital city of Cameroon?"
    - Sometimes we retrieve relevant information that allows us to answer questions even when we don't have the exact fact stored
2. **Employ mental imagery and inference**
    - Example: "How many windows are there in your current residence?"
    - Most people answer by mentally walking through their residence and counting, rather than retrieving a stored number
    - We use inference: "Did Julius Caesar have toes?" → Most people have toes, so Caesar likely did too
    - "Do elephants eat more than lions?" → Large animals tend to eat more, so elephants likely eat more
3. **Relate new events to prior knowledge**
    - Helps understand new information by connecting it to existing knowledge
4. **Deliver relevant knowledge when needed**
    - Accessing the vast store of knowledge in memory is a crucial memory function

### Processes of Memory

Three fundamental processes:

1. **Encoding (Storage)**
    - How is real-world experience translated into memory representations?
    - What is the nature of these representations?
    - What strategies can improve encoding?

2. **Storage**
    - How is information maintained in memory?
    - What is memory capacity?
    - How is information kept and lost?
    - How do encoding factors affect storage?
3. **Retrieval**
    - How is information retrieved when needed?
    - What strategies increase successful retrieval?
    - How do encoding and storage factors affect retrieval?

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# 2. Short-Term Memory (STM)

## Introduction

**Definition:** Also called primary memory—the mechanism that keeps information active and available.

**Example:** When given a password you cannot write down, you repeat it to yourself to keep it active.

**Why STM is useful:**

1. **For further processing:** Attended information is registered in STM, making it available for:
    - Further processing
    - Permanent storage
2. **For using recalled information:** When information is recalled from permanent memory into STM, it becomes available for further processing
    - Example: Recalling a sibling's birth date, then calculating their age
    - Example: Keeping incomplete information from the world, then augmenting it with knowledge from memory

## Characteristics of Short-Term Memory

**Rehearsal and Forgetting**

**Maintenance (primary) rehearsal:**

- We can maintain memory for a few letters, numbers, or words almost indefinitely if we rehearse them repeatedly
- Each repetition imprints items in memory anew
- However, we cannot keep rehearsing indefinitely because we encounter other items

**Forgetting in STM results from:**

1. **Additional tasks that interfere with rehearsal**
    - Example: Trying to rehearse letters while counting backwards by threes (97, 94, 91...)

    - The interference task disrupts rehearsal

2. **Limited capacity of STM**
    - New items may enter STM and crowd out existing items

**Coding in Short-Term Memory**

**How is information encoded in STM?**

Research shows various encoding types:

- **Acoustic codes:** Illustrates importance of verbal rehearsal
- **Visual codes**
- **Semantic (meaning-related) codes**

**Limitations and Chunking**

**Observations:**

1. **Numbers:** Easier to remember "10, 20, 30, 40, 50, 60, 70, 80" than "50, 30, 60, 20, 80, 10, 40, 70"
    - We remember the pattern (increments of 10) rather than exact order
2. **Letters and words:** Easier to remember 52 letters forming "I pledge allegiance to the flag of the United States of America" than 10 random letters "R, P, L, B, V, Q, M, S, D, G"
    - An American only needs to remember it's the Pledge of Allegiance, not the exact letters

**Chunk:**

- The code used to store information in short-term memory
- Any meaningful group of information
- You don't store every piece—you store the idea that the chunk occurred
- To retrieve: retrieve the idea from STM, then retrieve constituents from long-term memory

**Key points:**

- Chunking depends on previous knowledge—what is meaningful depends on what we know
- Example: "CRTV BBC CNN" is easier to remember than "C RT VBB CCNN" (if you know these TV networks)

**Memory span: 7 ± 2 (or 5 to 9)**

- Theoretical number of chunks of information that can be stored in short-term memory

## Working Memory

**Definition:** A brain and cognitive system that provides temporary storage and manipulation of information necessary for complex cognitive tasks.

**Baddeley's Model of Working Memory:**

Consists of:

- **Central executive** (coordination)
- **Two specialized subsystems:**
    1. **Phonological loop**
    2. **Visuospatial sketchpad**

**Phonological Loop**

**Two parts:**

1. **Phonological store**
    - Holds acoustic or speech-based information for about 2 seconds
    - Explains why if you hear someone talking but don't pay attention, you can usually repeat the last part of their speech if asked
    - The phonological store still has the last 2 seconds of speech
2. **Articulatory control process**
    - Produces inner speech (the voice we hear in ourselves)
    - Allows subvocal rehearsal, refreshing the phonological store to keep information available

**Alternative interpretation of memory span:**

- **Chunking interpretation:** Span is the number of chunks held in STM
- **Phonological loop interpretation:** The time it takes to rehearse information is what matters
    - If chunks are fast to rehearse, memory span is greater

**Visuospatial Sketchpad**

- Allows manipulation of visual and spatial objects
- Operates differently from the phonological loop
- **Independence:** Use of the sketchpad is interfered with by other visual tasks, but not by verbal tasks
- Similarly, the phonological loop is interfered with by verbal tasks, but not by visual tasks

**Central Executive**

- Functioning not well understood
- Believed to coordinate the phonological loop and visuospatial sketchpad

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# 3. Long-Term Memory (LTM)

## Introduction

**Key characteristic:** Items that enter the memory system and survive the first few seconds may be retained for long periods.

**Important questions:**

- Why does memory sometimes fail or mislead us (e.g., memory changes over time)?
- Why do we have difficulty recalling names, dates, etc.?
- How do people figure out relevant information to retrieve from the huge store of knowledge for the task at hand?

## Free Recall

**Technique:** Subject presented with a list of words and asked to reproduce as many as possible from memory.

**Typical results:**

- Only 10 to 20 words recalled out of 50

**Serial position effect:**

- Probability of recalling an item depends on where it appeared on the list
- **Primacy effect:** Items at the beginning are more likely to be recalled
- **Recency effect:** Items at the end are more likely to be recalled
- Items in the middle are least likely to be recalled

**Effect of delay (30 seconds with distracting task):**

- Recall of items at the end (recency effect) suffers
- Performance at beginning and middle remains the same

**Interpretation:**

- **Recency effect:** Items at end were recalled from STM (phonological loop of working memory); distracting task eliminated this advantage
- **Other items:** Recalled from long-term memory (not affected by distraction)

**Primacy effect explanation:**

- Items added earlier (top of list) were not quickly bumped out (still within STM capacity limit)
- They stayed longer in STM, were rehearsed longer, and had the best opportunity to be transferred to long-term memory

## Encoding

**Definition:** The initial processing of an item that leads to a representation of it in memory.

**Four encoding influences on memory:**

1. **Levels of processing**
2. **Memory for meaning**
3. **Organization**
4. **Elaboration**

**Levels of Processing**

- An item can be processed in many ways
- Resulting memory depends on the level or depth of processing

- **Continuum:** From shallow analysis of physical characteristics to deeper level of meaning
- Deeper processing generally leads to better memory

**Memory for Meaning**

**Key point:** Often we don't need to remember precise words, but rather their meaning.

**Example:** Given "Three turtles rested on a floating log and a fish swam beneath it."

- When asked if you read that "the fish swam under the turtles," you're likely to say Yes
- Research shows people cannot distinguish between literal information and natural inferences
- However, they detect changes that alter meaning (e.g., substituting "on" with "beside")

**Organization**

- Memory for an item often depends on other items present
- If items are organized, performance increases

**Example experiment:**

- Items organized by category vs. random order
- Recall was much better when categorized (65% vs. 18%)
- After 4 trials, both improved, but random condition was still 63% less than organized condition

**Application:** Good students have information well organized in memory

**Elaboration**

- When presented with information, we not only encode meaning but also elaborate or explain it
- **Example:** Seeing someone at a door with an umbrella → elaboration: "she believes it might rain"
- If later asked if the woman had an umbrella, we're more likely to remember if we had elaborated earlier
- Elaborations help augment incomplete information with further knowledge from memory and interpret it

## Retrieval

**Definition:** Remembering encoded information.

**Example experiment:**

- Name as many animals as possible in one minute
- Name as many countries in Africa as possible in one minute
- **Result:** More countries named than animals, even though there are more animals than African countries

**Why?**

- Easier to name countries rapidly because one can use a natural retrieval plan
- **Example retrieval plan:** Geographic location (Southern Africa, East Africa, Central Africa, West Africa, North Africa)

- Retrieval plans could be used for animals too (domestic, wild, etc.), but they don't provide systematic order—one often repeats names already mentioned

**Retrieval plan characteristics:**

1. **Cues should be organized** such that no cue is likely to be forgotten
    - Example: Remembering regions in Cameroon by moving from one geographic location to the next
2. **Each cue should lead to recall** of a number of items not recallable from other cues
    - Should do so systematically (avoiding repetition and missing items)

## Encoding-Retrieval Interactions

**Key principle:** Memory for events is affected by more than simply encoding and retrieval separately.

**Library analogy:**

- Easy to find books because of good organization and retrieval system
- Catalogue records position of every book
- Same catalogue used to search and retrieve books
- **Crucial point:** Same cues used for encoding (recording) and retrieving information
- Much better than trying to retrieve by unrelated cues (e.g., "green cover, author named Smith")

**Three points regarding encoding-retrieval matching:**

1. **Encoding specificity**
2. **Context change**
3. **Spacing effect**

**Encoding Specificity Principle**

**Definition:** Matching the encoding contexts of information at recall assists in retrieving memories.

- Memory for an item is affected by the match of encodings at learning and retrieval
- Provides framework for understanding how encoding conditions relate to memory and recall

**Recognition vs. Recall:**

- **Recognition:** Generally more accurate than recall
    - Reason: Individual is presented with more of the context of the original experience
- **But recall can be superior** in some situations
    - Explained by encoding specificity principle

**Example:**

- Given word pairs (e.g., "river bank") and asked to remember the second word
- Later given one of two tests:
    1. **Recognition test:** Given "piggy bank" and asked if you remember seeing "bank" on the original list

2. **Cued recall test:** Given cue "river" and asked to recall the word it was paired with

- **Result:** Performance better in recall test
- **Why:** In recognition, "bank" has different meaning (financial institution vs. river edge)
    - Word was encoded with different meaning, not recognized
    - In cued recall, you recall word consistent with meaning used in encoding

**Context Change**

**Context:** All information that might be encoded aside from the item of interest.

**Context effects:** Improvement (or decrement) in memory of having information occur with the same (or different) context in which it was encoded.

**Two types of context cues:**

1. **External cues** (e.g., physical environment)
    - Recall is better in the same physical setting where learning (encoding) took place
    - Example: Experiments show recall facilitated if test is in same room as learning
    - Effect more difficult to obtain with recognition (not recall) as the measure
2. **Internal cues** (e.g., body states)
    - How one feels inside can partially determine how items are encoded and retrieved
    - **Example 1:** Person who drinks too much one night may have little memory the next day
        - Memory failure not permanent—may recover memory next time they drink too much
    - **Example 2:** Mood—people sometimes recalled more if in same mood (happy or sad) at study and test

**Spacing Effect**

**Definition:** The observation that repetitions spaced in time tend to produce stronger memories than repetitions massed closer together in time.

**Examples/applications:**

- For customer to remember advertisement better: space it out, don't play same commercial back-to-back
- Spacing out multiple study sessions over long period enhances long-term learning and retention
- Far better than cramming the night before an exam

**Possible reasons:**

1. When repetitions occur further apart, they are more likely to be encoded under different contexts
    - Leads to multiple ways to retrieve the information
2. The repetitions may be reminding the learner of the earlier presentation
3. Learner stores information about changes in encoding and context from the prior presentation

**Long-term spacing:**

- Most studies consider short spacings and delays
- But effect works over long periods as well
- **Example:** Foreign language vocabulary study
    - Learning done over 14-day, 28-day, 56-day intervals for various groups
    - Recall declined over years as expected
    - But consistently, recall was better the longer the interval between learning

## Forgetting

**Common experience:** We know the answer to a question but it seems to slip our minds temporarily.

**Questions:**

- What happened to the missing items?
- Are they permanently lost or still in memory?
- What caused the forgetting?

**Not Remembering vs. Permanently Forgetting**

**Current thinking:** Once entered into long-term memory, most items are not lost but may be retrievable only under certain circumstances.

**Example: Intentional forgetting experiment**

- Subjects shown lists of items to remember
- Partway through some lists, subjects signalled to try to forget everything preceding the signal
- **Results:**
    - **Recall test:** Subjects unlikely to remember items preceding forget signal (suggesting loss from storage)
    - **Recognition test:** Subjects able to recognize forget items as belonging to list (demonstrating items were not lost)

**Conclusion:** Items were not permanently lost—they were just not accessible via recall, but were accessible via recognition.

**Causes of Forgetting**

**Observation:** Memory gets worse (we tend to forget) with time.

**Three main hypotheses:**

1. **Decay**
2. **Interference**
3. **Overwriting**

#### Decay

**Hypothesis:** Memories that are not recalled or studied for a period of time lose strength in memory as a result of an automatic process of decay.

- If you haven't thought of an event for a while, the longer this period, the less likely you'll remember it

- **However:** Very difficult to find support for the memory decay hypothesis

#### Interference

**Hypothesis:** Forgetting is a result of interference from other material on earlier items.

**Two types:**

1. **Retroactive interference:** Forgetting caused by later learning
2. **Proactive interference:** Earlier learning interfering with related material learned later

**Typical experimental setting (retroactive interference):**

| Group | Original Learning | Interpolated Learning | Test |
|---|---|---|---|
| Experimental | List A | List B | List A |
| Control | List A | Rest | List A |

- **Typical finding:** Recall for List A is poorer for experimental group than control group
- Learning List B interferes with recall of List A

**Typical experimental setting (proactive interference):**

| Group | Original Learning | Interpolated Learning | Test |
|---|---|---|---|
| Experimental | List B | List A | List A |
| Control | None | List A | List A |

- **Typical finding:** Recall for List A is poorer for experimental group than control group
- Learning List B first interferes with later learning of List A

#### Overwriting

**Hypothesis:** Our memories may be changed by later events so that the original memories cannot be retrieved because they no longer exist.

**Example:**

- First roller coaster ride encoded
- Second ride encoded later
- Overwriting: Originally encoded part is replaced with related part of later event (second ride)

**Implications:** Important for understanding misleading questions in eyewitness testimony—later information can overwrite original memories.

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## Quick Reference

| Topic | Key idea |
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| Memory uses | Store facts, use inference/imagery, relate new to prior knowledge, deliver relevant knowledge |
| Encoding | Initial processing leading to memory representation |
| Storage | Maintaining information in memory |
| Retrieval | Accessing stored information when needed |
| STM | Primary memory—keeps information active and available |
| Maintenance rehearsal | Repeating to keep items in STM |
| Chunking | Meaningful groups stored as single units; depends on prior knowledge |
| Memory span | 7 ± 2 chunks |
| Working memory | Temporary storage and manipulation for complex tasks |
| Phonological loop | Acoustic/speech information (2 seconds); articulatory rehearsal |
| Visuospatial sketchpad | Visual and spatial object manipulation |
| Central executive | Coordinates subsystems |
| Serial position effect | Primacy (beginning) and recency (end) better recalled |
| Levels of processing | Deeper processing → better memory |
| Memory for meaning | We remember meaning, not exact words |
| Organization | Organized items recalled better |
| Elaboration | Explaining/expanding information improves memory |
| Retrieval plans | Systematic cues for accessing information |
| Encoding specificity | Matching encoding and retrieval contexts improves memory |
| Context effects | Same context (external/internal) improves recall |
| Spacing effect | Spaced repetitions → stronger memories than massed |
| Decay | Automatic loss over time (difficult to support) |
| Retroactive interference | Later learning interferes with earlier |
| Proactive interference | Earlier learning interferes with later |
| Overwriting | Later events replace original memories |