Long-Term Memory: Encoding & Retrieval
Chapter 7

Some Questions to Consider

• What is the best way to store information in long-term memory?
• What are some techniques to help us get information out of LTM when we need it?
• How can the results of memory research be used to create more effective study techniques?
• How is it possible that a lifetime of experiences and accumulated knowledge can be stored in neurons?

Storing Information in LTM

• **Encoding**: acquiring information and transforming it into memory
• **Maintenance rehearsal**
  • Maintains information but does not transfer it to LTM (simple repetition)
• **Elaborative rehearsal**
  • Think about the meaning. Transfers information to LTM.
Levels of Processing Theory

- Memory depends on how information is encoded
- Depth of processing
  - **Shallow processing**: e.g., little attention to meaning (poor memory)
  - **Deep processing**: e.g., close attention to meaning (good memory)

Demonstration

On each of the next 18 slides, you will see a question followed by a word. Say either “yes” or “no” depending upon whether the word answers the question.

1. Does it rhyme with stick?

**party**
2. Is it typed in small letters?

   TREE

3. Does it fit in the sentence, "A ____ swam in the pond"?

   DUCK

4. Is it typed in small letters?

   fox
5. Does it rhyme with bell?  
   **color**

6. Does it fit in the sentence, "My ____ is six feet tall"?  
   **penny**

7. Does it rhyme with shook?  
   **look**
8. Is it typed in capital letters?  
   flower

9. Does it fit in the sentence, “The ____ was building a nest”?  
   ROBIN

10. Is it typed in capital letters?  
    SNOW
11. Is it typed in small letters?

MARKET

12. Does it fit in the sentence, "Pat drove the ___ into town"?

HOUSE

13. Does it rhyme with small?

HALL
14. Does it rhyme with weight?

  gate

15. Does it fit in the sentence, "I drank a cup of ____ today"?

  window

16. Is it typed in small letters?

  book
17. Does it fit the sentence, "The ____ finished the exam"?

pupil

18. Does it rhyme with blue?

SAFE

Levels of Processing

- Developed by Craik & Lockhart (1972)
- Information retention depends on the kind of processing you do at encoding (deep vs. shallow processing)
- Demo: Write down as many of the 18 words (printed in blue) as you can recall.
a) Sequence of events in Craik & Tulving’s (1975) experiment.

b) Results of this experiment. Deeper processing (fill-in-the-blanks question) is associated with better memory.

Beware of Circular Reasoning!

• Which task causes deeper processing?
  • Using a word in a sentence
  • Deciding how useful an object might be on a desert island
  • Can you empirically measure the memory trace in each condition?
    • No, we conclude that stronger memory trace must have been caused by deeper processing
    • But depth of processing has not been defined independently of memory performance
    • Therefore, this is circular reasoning
The circularity of defining depth of processing in terms of memory and then predicting that deeper processing will result in better memory.

Other Factors that Aid Encoding

- Imagery
- Creating connections, cues for remembering
- Self-reference effect
- Generation effect
- Organizing to-be-remembered information
- Testing

Imagery

- Paivio and his associates initially determined quantitative imagery values for each of a long list of nouns (Paivio, Yuille, & Madigan, 1968).
- Concrete nouns such as ‘cat’ have high imagery values, and abstract nouns such as ‘truth’ have low ones, although there are exceptions to this rule.
- Once these quantitative imagery values were established, Paivio was able to show, in various experimental designs, that words with high imagery values were consistently remembered significantly better than those with lower ones.
For imagery-based mnemonics to work, the images you create have to be integrated.

Evidence: Bower & Winzenz (1970)

Three mnemonic conditions:
- Overt rote rehearsal
  - 30% recall
- Noninteracting imagery
  - 27% recall
- Interacting imagery
  - 53% recall

Interacting images do NOT have to be bizarre to be effective.

Generation effect:

- The robust finding that information will be better remembered if it is generated rather than simply read.
- Memory is better for self generated content in tests using free recall, cued recall, and recognition:
  - List of words
  - Math problems
  - Pictures
Generation Effect

- Study Conditions:
  - Semantic/synonym
    - Generate Synonym: save - k___?
    - Read: save - keep
  - Rhyme
    - Generate Rhyme: sleep - k___?
    - Read: sleep - keep
- Rhyming Recognition Test:
  - Rhymes with studied words: beep
  - Does not rhyme with studied words: switch
  - “Does test word rhyme with target word?”

Organization, Comprehension, and Memory

- Bransford & Johnson (1972)
- Presented participants with difficult-to-comprehend information
  - **Experimental Group 1** first saw a picture that helped explain the information
  - **Experimental Group 2** saw the picture after reading the passage
  - **Control Group** did not see the picture
- Group 1 outperformed the others.
  - Having a mental framework of comprehension aided memory encoding and retrieval

“If the balloons popped, the sound wouldn’t be able to carry since everything would be too far away from the correct floor. A closed window would also prevent the sound from carrying, since most buildings tend to be well insulated. Since the whole operation depends on a steady flow of electricity, a break in the middle of the wire would also cause problems. Of course, the fellow could shout, but the human voice is not loud enough to carry that far. An additional problem is that a string could break on the instrument. Then there could be no accompaniment to the message. It is clear that the best situation would involve less distance. Then there would be fewer potential problems. With face to face contact, the least number of things could go wrong.”
Testing Effect

- Which results in a stronger memory trace?
  - Re-reading the material
  - Being tested on the material
  - Roediger and Karpicke (2006) had participants read a passage and then either...
    - recall as much as they could.
    - reread the passage.
    - Tested recall after a delay...

  - Note that at longer times after learning, the performance of the testing group is better than the performance of the re-reading group.
Retrieving Information from LTM

- **Retrieval**: process of transferring information from LTM back into working memory (consciousness)
- Most of our failures of memory are failures to retrieve

Cued Recall

- Tulving & Pearlstone (1966)
- Mantyla (1986)
- Chapter 7, Page 183

Encoding Specificity

- We learn information together with its context
- Baddeley's (1975) "diving experiment"
- Best recall occurred when encoding and retrieval occurred in the same location
• (a) Design for Godden and Baddeley’s (1975) “diving” experiment.

• (b) Results for each test condition are indicated by the bar directly under that condition.

• (a) Design for Grant et al.’s (1998) “studying” experiment.

• (b) Results of the experiment.

State-dependent learning:
Mood study

State-dependent learning: Alcohol study

Encoding Specificity vs. Encoding Variability
- The encoding specificity principle is robust, but it may NOT be effective under certain circumstances
- If you know exactly what the retrieval context will be like:
  - Maximize the match between encoding and retrieval (= encoding specificity)
    - But your memory will be tied to those specific encoding/retrieval contexts (rigid memory that does not generalize to other contexts)
    - Example: Relying exclusively on one study method (e.g., flashcards)
- If you don’t:
  - Encode information in various ways (= encoding variability)
  - Your recall is likely successful in different retrieval contexts

Transfer-Appropriate Processing
- Better test performance when study and test conditions are the same vs different.
- Group 1: study words in *rhyming* condition.
  - Does each test word rhyme with a study word?
- Group 2: study words in *meaning* condition.
  - Does each test word rhyme with a study word?
- Study–test match had better memory. Problem for LOP?

Morris et al. (1977)
### Improving Learning and Memory

- **Elaborate**
  - Highlighting is not enough!
- **Generate and test**
- **Organize**
  - Helps reduce load on memory
  - Match learning and testing conditions

### Improving Learning and Memory

- **Associate** what you are learning to what you already know. Make *connections* within and between chapters.
- Avoid the “illusion of learning”
  - *Familiarity does not mean comprehension*
- **Take breaks**
  - Memory is better for multiple short study sessions
  - Allows for consolidation

### Study tips from cognitive psychology

- Elaborative encoding
- Encoding variability
- Spaced studying
- Self-testing

* (Ch 7, pp. 187–189 of textbook)
Elaborative encoding

- Learning is most effective when you elaborate on the meaning of the material.
- Verbatim copying is ineffective.
- Take meaningful notes
  - Paraphrase!
- Generate your own associations.
- Don’t confuse familiarity with understanding!

Encoding variability

- Learning is better when each study episode gives a slightly different perspective.
- e.g., Try to integrate my notes with your own notes.
- Think about the topics in relation to other chapters.

Spaced studying

- Given a constant amount of study time, memory will be better if you space your study efforts out across time.
- Don’t cram!
- Study regularly through the week, not just before a test.
- Read early, listen attentively, review later.
- Spacing helps across days and within days (e.g., read psych in the morning, biology in the afternoon).
Self-testing

- Re-reading is NOT an efficient method of studying. You'll remember things better and take less time if you practice generating your own answers.
- A test won't ask you to read notes, so why practice that?
- Learning process benefits from self-testing
  - Retrieving information is effective for strengthening memory.
  - Testing forces you to identify gaps in understanding.

Information Storage at the Synapse

- Long-term potentiation (LTP)
- Enhanced firing of neurons after repeated stimulation
- Structural changes and enhanced responding
- Hebbian Learning
- **Potentiation**: to make potent or powerful
- LTP is a chemical process for increasing synaptic strength.

1. What happens at a synapse as a stimulus is first presented.
2. As the stimulus is repeated, structural changes are beginning to occur (more receptors).
3-4. After many repetitions, more complex connections have developed between the two neurons, which causes an increase in the firing rate, even though the stimulus is the same on that was presented initially.

If you want to know more, take Jerry Rudy's course: Neurobiology of Learning & Memory
Where Does Memory Occur in the Brain?

- Medial temporal lobe
- Hippocampus
- Perirhinal cortex: subsequent memory effect (Davachi et al., 2003)
- Parahippocampal cortex: spatial information
- Amygdala: fearful/emotional memories

Brain Areas Related to Memory Retrieval

- (a) Side view of the brain
- (b) Underside of the brain, showing the amygdala (fear conditioning) and structures in the medial temporal lobe (perirhinal cortex, parahippocampal cortex, entorhinal cortex, and hippocampus; essential for episodic memory).
The Fragility of New Memories

- Retrograde amnesia: loss of memory for events prior to the trauma
- Anterograde amnesia: cannot form new memories
- Memory for recent events is more fragile than for remote events (graded amnesia; Ribot’s Law, 1881)

Consolidation

- Transforms new memories from fragile state to more permanent state
  - **Synaptic consolidation** occurs at synapses, happens rapidly via LTP
  - **Systems consolidation** involves gradual reorganization of circuits in brain

Consolidation

- Standard model of consolidation
  - Retrieval depends on hippocampus during consolidation; after consolidation hippocampus is no longer needed
  - Reactivation: hippocampus replays neural activity associated with memory. Eventually hippo is not necessary.
- Controversial topic

Squire & Alvarez (1995)
• (a) According to the **standard model of consolidation**, retrieval of recent memories depends on the hippocampus; cortical connections have not yet formed. Thus, for retrieval of recent memories, hippocampal activation is high and cortical activation is low.

• (b) Once consolidation has occurred, cortical connections have formed, and the hippocampus is no longer needed. Thus, for retrieval of remote memories, cortical activation is high, and there is no hippocampal activation.

**Consolidation**

- Multiple trace hypothesis
  - Questions the assumption that the hippocampus is important only at the beginning of consolidation:
    - **Hippocampus is always necessary to access info in cortex.**
    - The hippocampus has been shown to be activated during retrieval of both recent and remote memories (Gilboa et al., 2004)

Nadel & Moscovitch (1997)

**Are Memories Ever “Permanent”?**

- Understanding human memory is a “work in progress”
- Reactivation and reconsolidation research on animals
  - Nader et al. (2000)
    - Fear condition in rats
      - Can erase a memory while it is being remembered
“He thought each memory recalled must do some violence to its origins. As in a party game. Say the word and pass it on. So be sparing. What you alter in the remembering has yet a reality, known or not.”

The Road, by Cormack McCarthy