Chapter 5
Episodic Memory: Organizing and Remembering
Endel Tulving’s Distinction

**Episodic Memory**
- Memory that allows you to access *specific events* located at a particular point in time
- “Mental time travel”
  - Backward: to relive earlier episodes
  - Forward: to anticipate and plan future events

**Semantic Knowledge**
- Generalized knowledge of the world
- May arise through the consolidation of numerous episodic memories
  - e.g. Conway et al., 1992:
    - Short delay: information is recalled in episodes
    - Long delay: the same information had been integrated into semantic memory
System Requirements

- Distinguishing *individual episodes* requires:
  - A system that can catalog unique events so that one event can be distinguished from another.
  - A method for storing the events durably.
  - A method for searching and retrieving the events.
Approaches to Studying Memory

**Ebbinghaus**
- Ran carefully controlled experiments in the laboratory.
  - He was criticized for focusing on narrow issues and phenomena.
  - He largely ignored how memory works in the real world.
  - He went to lengths to strip study materials of any pre-existing meaning (e.g., nonsense syllables) – not avoiding meaning but avoiding familiarity confounds.

**Bartlett**
- Studied the recall of complex material (e.g. drawings and folk tales) – *War of the Ghosts* pg 94
  - Examined recall errors to understand encoding and storing processes.
  - Used informal testing methods
  - Stressed participants’ *effort after meaning*.
  - Assumed *schemas*: long-term structured knowledge used to make sense of new material and subsequently store and recall it.
  - Schemas are influenced by social and cultural factors.
More on Bartlett’s Methodology

Bartlett believed:
- Systematic recall errors and distortions are often caused by schemas intruding on reality.
- Appropriate schemas help memory, e.g. Bower, Karlin, and Dueck’s (1975) “droodles”.

Bartlett was criticized for:
- Failing to conduct/report statistical tests.
- Providing only vague instructions to his participants.
  - These instructions may have produced deliberate guessing, amounting to the memory distortions of interest.

Many of Bartlett’s findings still stand the test of time, however.
Tests of Bartlett’s Theory

Sulin and Dooling (1974)

Hypothesis:

- Schema-driven errors are more likely at longer retention intervals because schematic information is more durable than rote recall.

Task and Results:

- Presented all participants with the same story about a dictator, whose name was either: Gerald Martin (an unknown) or Adolf Hitler (someone well known historically).
- Asked participants whether they remembered reading a statement that the dictator “hated Jews,” which did not appear in the story. Delay time was varied:
  - Short (5 minutes): No difference between groups
  - Long (1 week): Participants who read about Hitler were more likely to incorrectly agree that they had read a statement about Jews, influenced by schematic knowledge about the real Hitler.
Tests of Bartlett’s Theory
Carmichael, Hogan, and Walter (1932)

- **Task:**
  - Presented participants with a series of ambiguous objects (e.g. could either be a hat or a beehive) along with one of those labels (list 1 or 2)
  - Later, asked them to draw the objects

- **Results:**
  - The label influenced people’s drawings

- **Conclusion:**
  - The label biased the perception and storage of the objects

However, Prentice (1954) conducted a follow-up:

- **Methods:**
  - Same as for Carmichael, Hogan, and Walter (1932), but instead of asking participants to draw the objects, they were simply asked to *recognize* the objects

- **Results:**
  - The label effect disappears under recognition conditions

- **Conclusion:**
  - The bias observed by Carmichael, Hogan, and Walter arose during *retrieval* rather than encoding because the items recognized were not the distorted ones drawn in the previous recall task, but the original figures.
Meaning and Memory

- Not all “nonsense” syllables are created equal:
  - Even “nonsense” syllables can take on meaning
    - e.g. CAS might prompt participants to think of CASTLE
  - Syllables rated as more meaningful are easier to recall
  - However, there wasn’t enough time to form such associations in Ebbinghaus’s study.

- Studying memory for nonsense syllables is most likely a study of the formation of *repetition habits*, as Bartlett suggested.
  - Syllables that most closely follow the structure of English are easiest to acquire
Meaning and Memory

Test Methods

- Testing word learning, rather than nonsense syllables involved:
  - **Serial recall**: Recall all the words in the list, in order
  - **Associative recall**:
    - e.g. *study*: DOG–BISHOP; *Test*: DOG–?
    - Strongly related pairs (e.g. DOG–BONE) are more memorable.
  - **Free recall**: Recall as many words from the list as possible, in *any* order.
    - Lists with many inter-word associations are more easily recalled (Deese, 1959).
    - Related words within a list tend to be recalled in a cluster (Jenkins & Russell, 1952).
Meaning and Memory

Visual Imagery

- Paivio (1969; 1971):
  - Words rated as being more imageable (e.g. concrete nouns) are more memorable.
    - Low-imageability examples: VIRTUE, HISTORY, DISSENT, IDEA
    - High-imageability examples: CHURCH, BEGGAR, ARM, TEAPOT
  - The results are explained in terms of the **dual-coding hypothesis**:
    - Imageable words can be encoded both in terms of:
      - Visual appearance
      - Verbal meaning
    - Availability of multiple retrieval routes improves the chance of successful recall.
The sly young fox ____ to eat the little ____ hen for his dinner.

_____ made all sorts of _____ to catch her. He _____ many times to _____ her. But she was _____ clever little hen. Not _____ of the sly fox’s _____ worked. He grew quite _____

trying to catch the _____ red hen.
The sly young fox wanted to eat the little red hen for his dinner. He made all sorts of plans to catch her. He tried many times to catch her. But she was a clever little hen. Not one of the sly fox's plans worked. He grew quite thin trying to catch the little red hen.
Learning and Predictability

- Sentences are more memorable than random word strings because:
  - Words in a sentence tend to be more related than in unrelated word strings.
  - Words in a sentence are somewhat predictable due to linguistic redundancy built in by grammar and semantics – not equally probable.

- The Cloze technique:
  - A measure of redundancy in language.
  - Task:
    - Ask individuals to fill in sentences where every fifth word is missing (like Mad Libs, e.g. “The dog chased his ____.”
  - Results:
    - The more redundant and predictable the prose (text), the easier it is to recall. Children’s story was easier than Wuthering Heights.
Levels of Processing Theory

Why does meaning facilitate LTM?

- **Levels-of-Processing Hypothesis** (Craik & Lockhart, 1972):
  - Information can be processed on a variety of levels, from the most basic (visual form), to phonology (speech sounds), to the deepest level (contextual meaning).
  - The depth of processing helps determine the durability in LTM.

<table>
<thead>
<tr>
<th>Level of Processing</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Visual Form</td>
<td>“DOG” includes the letters D, O, and G</td>
</tr>
<tr>
<td>2) Phonology</td>
<td>Rhymes with FOG</td>
</tr>
<tr>
<td>3) Semantics (Meaning)</td>
<td>A four-legged pet that often chases cats and chews on bones</td>
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</tbody>
</table>
Levels of Processing
Craik and Tulving (1975)

**Task:**
- Participants viewed words and were asked to make three different types of judgments:
  - Visual processing (e.g. “Is LOG in upper case?” Y/N)
  - Phonological (e.g. “Does DOG rhyme with LOG?” Y/N)
  - Semantic (e.g. “Does DOG fit in the sentence: ‘The ___ chased the cat’?” Y/N)
- Finally, participants were asked to recognize the words they had seen before in a surprise test including both old and new words.

**Results:**
- Words that were more deeply processed were more easily recognized -- particularly for questions with a “YES” response.
Levels of Processing
Craik and Tulving (1975)

Conclusions:

- “Yes” responses were better recalled because these items are better integrated with the encoding question.
- In the semantic condition, especially, the sentence context provided a reminder during the test.
- While semantic judgments typically take longer to make, the slower processing rate is not the cause of this effect.
- Slowing down the shallower levels of processing by increasing the judgment difficulty did not affect memorability in a follow-up experiment.

Based on Craik and Tulving (1975).
Levels of Processing

Generalizability

- The levels-of-processing effect is found:
  - Across numerous encoding tasks.
  - On both recognition and recall tests.
  - Regardless of whether participants expect a final test.

- Limits to the levels-of-processing hypothesis:
  - It is difficult to operationally define depth of processing.
    - As we’ve seen, we can’t use processing speed to define it.
    - Different levels of processing can occur simultaneously, rather than in series, making them hard to separate in a task.
  - Deeper processing does not always lead to better performance.
Transfer-Appropriate Processing

- **The Transfer-Appropriate Processing Principle:**
  - The processing requirements of the test should match the processing conditions at encoding in order to reveal prior learning.

- Morris, Bransford, and Franks (1977) tested the principle:
  - **Task:**
    - Participants made either a phonological or semantic judgment about each item on a word list.
    - The learning was **incidental**: participants were not told that they would have to later recall the words.
    - This constrains (limits) the learning strategies used.
  - The final test was either:
    - A standard recognition test for the learned words.
    - A rhyming recognition test for learned words – e.g., Was a word presented that rhymed with “bar”?
Transfer-Appropriate Processing
Morris, Bransford, and Franks (1977)

- **Results:**
  - Standard recognition test: Deeper processing led to better performance.
  - Rhyming recognition test: The shallower rhyme-based encoding task led to better performance because it matched the demands of the testing situation.

- **Conclusion:**
  - It only makes sense to talk about a learning method’s efficiency in the context of the type of final test.

- Follow-up by Fisher and Craik (1977):
  - They replicated these findings but emphasized the overall advantage for deeper processing.
Elaboration enhances retrievability:
- William James (1890) was among the first to highlight the benefit of weaving together associations between items.
- Semantically richer sentences make the words within them more memorable (Craik & Tulving, 1975).
- Elaborative rehearsal enhances delayed long-term learning more than maintenance rehearsal (Craik & Lockhart, 1972):
  - **Maintenance rehearsal**: Continuing to process an item at the same level at which it was encoded (e.g. rote rehearsal).
  - **Elaborative rehearsal**: Linking material being rehearsed to other material in memory.
Maintenance Rehearsal
Glenberg, Smith, and Green (1977)

Task:
- Participants were asked to remember numbers over a delay.
- During the delay, they had to read out words (purportedly to limit rehearsal on numbers), but really this was simulating maintenance rehearsal on the words.
- Some words were repeated only once during the delay; others were repeated many times.
- Participants then recalled the numbers followed by a surprise recall (or recognition) test for the words.

Results:
- Having nine times as many repetitions only increased recall by 1.5% (9% for recognition), suggesting that simple maintenance rehearsal doesn’t help long-term recall much.
Maintenance Rehearsal

Mechanic (1964)

- **Task:**
  - Participants had to repeat nonsense syllables either once or many times.
  - Only half of the participants were warned of an upcoming recall test.

- **Results:**

- **Conclusion:**
  - Knowing that there’s a test coming prompted additional processing in the intentional learning group.
  - Having to repeatedly articulate the word quickly discouraged either group from engaging in further processing.
### When Does Maintenance Rehearsal Work?

| Glenberg, Smith, and Green (1977) | Mechanic (1964) |
|-----------------------------------|----------------|---|
| **Finding:**                      | **Finding:**   |   |
| Maintenance didn’t help           | Maintenance did help in one condition |
| **Stimuli:**                      | **Stimuli:**   |   |
| Already known words               | Unfamiliar nonsense stimuli that need to be learned from scratch |
| **Rationale:**                    | **Rationale:** |   |
| The recall test relied on meaningful links between the known words (already in LTM), which depend on deeper, semantic features | Repeating unfamiliar stimuli with no natural links between them boosts their representation in phonological LTM |
Organization and Learning

Subjective Organization

- In contrast to learning nonsense syllables, when dealing with previously known words, nothing is being learned (represented in LTM).

- Instead, participants need to learn to select only the presented words from other words they already know.
  - Tulving (1962) found that people can do this through subjective organization:
    - Chunking together separate words for recall, even if those words weren’t presented together.
Organization and Learning

Subjective Organization

- Items are often chunked together if they:
  - Are linked to a common associate
    - e.g. SYRINGE, POINT, HAYSTACK, and KNITTING are all linked to NEEDLE
  - Come from the same semantic category (e.g. professions)
    - Simply cueing people with a category often improves recall
  - Form a logical hierarchical structure (Bower et al., 1969) or matrix (Cooper & Broadbent, 1978)
A Conceptual Hierarchy for Organizing Information

The “minerals” conceptual hierarchy used by Bower et al. (1969). Recall is much higher than when the same words were presented in scrambled order.
Organization and Learning

Strategies for Improving Memory

- Creating a story involving all the studied items.
  - Pros:
    - Given enough time and imagination, it’s possible to create a story for nearly any set of items.
    - Promotes elaborative encoding, building in links between items.
  - Cons:
    - Time intensive
    - Risk of recalling parts of the story that weren’t actually studied.

- Using visual imagery to have the studied items interact.
  - Pros:
    - Flexible and quick
  - Cons:
    - Best for concrete nouns, difficult for abstract nouns.
Intention to Learn

Mandler (1967)

- **Task:**
  - Participants get a deck of cards with a word on each and are divided into four groups, and asked to do one of the following:
    - Learn the words
    - Sort the cards into categories based on meaning.
    - Sort the cards by meaning knowing that they’ll be tested later.
    - Arrange the words in columns.

- **Results:**
  - Sorting by meaning with or without knowledge of the test produced the same level of recall.
  - Worst recall was found for incidental learning group asked to arrange the words into columns.

- **Conclusion:**
  - As long as you’re paying attention to the material, intention doesn’t matter, but level/type of processing does matter.
Memory and the Brain

- Scrub jay hiding food
  http://news.bbc.co.uk/2/hi/science/nature/8035950.stm

- Since episodic memory is arguably uniquely human, nonhuman animal studies are of limited value.

- Neuropsychological patients (like HM) who have deficits in episodic LTM often have damage to the Papez circuit.
  - Links the hippocampus and the frontal lobes
H.M.’s Brain

HM

Normal Brain

8 cm

Temporal lobe

Cerebellum

Hippocampus
Connections to the cortex result in feeling and consciousness. Connections to the hypothalamus result in bodily responses (ANS).
Memory and the Brain

The Aggleton and Brown (1999) Model

<table>
<thead>
<tr>
<th>Brain Region</th>
<th>Function</th>
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<tr>
<td>Hippocampus</td>
<td>Episodic recollection/recall</td>
</tr>
<tr>
<td>Surrounding rhinal and perirhinal cortex</td>
<td>Recognition memory</td>
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</tbody>
</table>

Aggleton and Brown argue that while the hippocampus is important, the surrounding rhinal and perirhinal cortex can support recognition, even when the hippocampus is compromised.

However, this remains a hotly debated and researched topic.
Perirhinal Hippocampus
(A) Simple schematic diagram of cortical–hippocampal connections.

Eichenbaum H et al. PNAS 1996;93:13500-13507
Further support for the Aggleton and Brown Model comes from Vargha-Khadem et al. (1997)

They tested three patients who became amnesic at an early age, including Jon.
- Jon has damage to his hippocampus.
- While he’s clearly amnesic, he has normal semantic memory.
  - This goes against the assumption that semantic memory depends on episodic memory, which, in turn, relies on the hippocampus.

Some have argued that Jon has just learned to adapt to his deficits, shifting the burden to another brain region since his brain was so young when the damage occurred.
Memory and the Brain

Episodic Memory and the Healthy Brain

- Brain activity can be recorded noninvasively using the electroencephalogram (EEG) and analyzed according to the response (ERP) evoked by the presentation of a stimulus that is repeated numerous times.

- The peaks and troughs occurring at particular times can be used to distinguish between different processes.

- However, this technique doesn’t afford the ability to determine where in the brain the activity is generated.
Memory and the Brain

The HERA Hypothesis (Tulving et al., 1994)

The Hemispheric Encoding and Retrieval Asymmetry (HERA) Hypothesis:

- Verbal encoding is supported by the left frontal region.
  - Especially with deep, semantically elaborated encoding (Gabrieli et al., 1998).

- However, nonverbal material tends to activate the right prefrontal area during encoding (Wagner et al., 1998).

- Episodic retrieval is supported by the right frontal region.

This hypothesis was formed on the basis of neuroimaging data; supportive neuropsychological data arose afterwards.
Event-related fMRI was used to disentangle the encoding-related brain activity of each photo stimulus.

This permitted a subsequent-memory analysis contrasting encoding activity for items that are later remembered in full episodic detail, those that simply felt familiar, and those that were later forgotten.

Subsequently remembered photos were associated with encoding activity in the right frontal lobe and bilaterally in the hippocampus.

Familiar and forgotten items did not activate these brain regions during encoding.

Wagner et al. (1998) replicated these findings using words as stimuli, finding activation in the left frontal lobe and the same two hippocampal areas found by Brewer et al.
fMRI Data for Remembered, Felt Familiar and Forgotten Items

Activation in the area of the hippocampus as a function of whether an item was subsequently remembered, judged familiar, or forgotten. High activation is associated with good recall. Data from Brewer et al. (1998).
Can we see signs of physical changes in the brain due to long-term learning?

- DeZeeuw (2007) discovered the growth of neural connections with learning.
- Experienced taxi drivers have larger posterior hippocampi than novice drivers (Maguire et al., 2001) or bus drivers who followed a regular route (Maguire et al., 2006).
  - The brain differences increased with more taxi experience.
  - Other regions in the hippocampus were smaller for experienced cab drivers.
  - Experienced cab drivers, though better at spatial navigation through London were worse at learning other visuo-spatial tasks, demonstrating their expertise comes at an expense.