Are there multiple LTM memory systems?

• How do you learn a new skill?
• How do you learn a new fact?
• How about learning about an event?

• Is there one long-term memory (LTM) system for these types of knowledge or are there multiple LTM systems?

Squire’s Taxonomy of memory

MEMORY

EXPLICIT

IMPLICIT

SEMANTIC (facts)

EPISODIC (events)

PRIMING (perceptual, semantic)

PROCEDURAL (skills)
Implicit and Explicit Memory

Implicit and explicit memory

• Implicit memory:
  past experiences influence perceptions, thoughts & actions without awareness that any info from past is accessed

• Explicit memory:
  conscious access to info from the past
  ("I remember that...")
  -> involves conscious recollection
  -> term often used synonymously with episodic memory

Explicit & Implicit MEMORY TESTS

Look at the following words. I will test your memory for these words in various ways.
SPONGE CANDY DOLPHIN
PACKAGE POSTER LICORICE
ZEBRA SECTION CAMOFLAGE
MISTAKE PORTAL KNAPSACK
COFFEE QUAIL ALPINE
HANDLE PANTRY CARPET
EAGER CELLO PRESSURE
LLAMA ORIOLE ACRID

EXPLICIT TEST OF MEMORY: RECALL
WRITE DOWN THE WORDS YOU REMEMBER FROM THE LIST IN THE EARLIER SLIDE

IMPLICIT TEST OF MEMORY: WORD FRAGMENTS
ON THE NEXT SLIDE, YOU WILL SEE SOME WORDS MISSING LETTERS, SOME "WORD FRAGMENTS" AND SOME ANAGRAMS. GUESS WHAT EACH WORD MIGHT BE.

EGNOPS *AN*Y *OL*H**
FAK**E** P*S*E* LICORICE
*E*RA SE*T*O* C**O*LA*E
*I*TA*E F**A**T**AL** KNAPSACK
*C*F*E*E* *U*IL AEILNP
*AN*LE *A*T*Y ACEPRT
*A*E* C*L** *RE*S**E
AALLM EIL**E** *C*ID
Implicit Memory Tasks

• **Word-fragment completion** is an implicit memory task. Fragments are (often) completed with words previously studied in the absence of an explicit instruction to remember the word.

• **Amnesiacs** often showed *spared implicit memory* → dissociation suggest different systems for implicit and explicit memory systems.

Implicit vs. Explicit Memory

• Graf, Squire, & Mandler (1984):

  – Study words: *cheese, house, …*

  – **Explicit memory test:** *cued recall.* Complete fragment to a word from study list: ch _ _ _ _

  – **Implicit memory test:** *word stem completion.* Complete fragment to form *any* word: ch _ _ _ _

Free recall, cued recall, recognition memory, and word completion in amnesic patients and controls.
Implicit/ Explicit Memory with Normals (Jacoby, 1983)

- Study conditions:
  - generate: give antonym to hot - ...
  - context: study word in context hot - COLD
  - no context: ... - COLD

- After study, two tests:
  - Explicit memory test: recognition memory
  - Implicit Memory test: improvement on perceptual identification test: how much more accurate can you identify a word flashed 40ms on screen when you have studied word before?

### Results

<table>
<thead>
<tr>
<th></th>
<th>Generate hot = high</th>
<th>Context hot = cold</th>
<th>No context xxx = cold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perception</td>
<td>0.7</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Recognition</td>
<td>0.7</td>
<td>0.2</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Semantic and Episodic Memory
Semantic and Episodic Memory

- **Semantic memory**
  - memory for facts about the world
  - can a canary sing?
  - who is secretary of state of the US?

- **Episodic memory**
  - memory for events in our lives (temporal organization)
  - what did you eat for breakfast?
  - where were you for the superbowl game?

- These are not always easy to distinguish. Facts about the world are learned through experience. E.g., you might remember learning in the news about the new secretary of state.

Category Specific Semantic Deficits

- Warrington and Shallice (1984) reported a patient called JBR who following an acute lesion to the left temporal lobe (as a result of herpes encephalitis) had a selective deficit when asked to name pictures from just one semantic category – living things.

- By contrast JBR was able to name non-living objects very well including those with low frequency names such as ‘accordion’ that were matched for the number of letters in the name and the visual complexity of the object.

- Other patients have shown opposite pattern

Summary of patient data

<table>
<thead>
<tr>
<th>Living</th>
<th>Nonliving</th>
<th>Artefacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal</td>
<td>Fruit</td>
<td>Artefacts</td>
</tr>
<tr>
<td>x</td>
<td>x</td>
<td>√</td>
</tr>
<tr>
<td>√</td>
<td>√</td>
<td>x</td>
</tr>
<tr>
<td>x</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>√</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>√</td>
<td>x</td>
<td>√</td>
</tr>
</tbody>
</table>
Implications

- One interpretation: multiple semantic memory systems (Warrington/Shallice). How many though?

- Alternative interpretation: unitary semantic memory system. Different types of objects depend on different types of encoding → sensory/functional approach

Sensory-Functional Approach

- Category specific effects on recognition result from a correlated factor such as the ratio of visual versus functional features of an object
  - living more visual and nonliving more functional.

- Farah & McClelland (1991) report a dictionary study showing the ratio of visual to functional features for living things and nonliving things:
  - living things was 7.7:1 and nonliving was 1.4:1.
A neural network model of category-specific impairments

- A single system with functional and visual features. Model was trained to discriminate 20 living and nonliving things
- Two main layers: semantic and input. Semantic has 3:1 ratio of visual and functional properties
- Objects have visual and functional property codes
  - 7.7:1 for living things
  - 1.4:1 for nonliving things

Simulating the Effects of Brain Damage by "lesioning" the model

Visual Lesions: selective impairment of living things
Functional Lesions: selective impairment of non-living things

Amnesia
Amnesia

- Types:
  - **Retrograde**: cannot remember old memories
  - **Anterograde**: cannot form new episodic memories

- Retrograde amnesia is more rare

- Sources
  - Blow to head, Concussion
  - Korsakoff syndrome (severe vit. B1 deficiency)
  - Alzheimer’s
  - Damage to hippocampus, thalamic structures
  - ECT (electroconvulsive shock therapy)
  - Midazolam: artificially induced amnesia

Brain Structures

Diagram of the limbic system and related structures. Areas indicated with an asterisk are known to be associated with memory function. From Parkin (2001).

- Anterograde amnesics often have damage to hippocampal areas
- Hippocampus may be involved in consolidation of memories – or may bind together elements of a memory
- Amygdala – important in formation of learned fears
- Prefrontal cortex – involved in memory for sequences and working memory.
Retrograde amnesia

- Temporal extent can vary:
  - ECT: months or weeks
  - Korsakoff’s, Alzheimer’s: years
- Temporal gradient:
  - Early memories are better remembered than memories before trauma
  - New memories continue to undergo neurological change: memory consolidation
- Retrograde amnesia often becomes less severe over time
  - Most remote memories are likely to return first
- Does not affect overlearned information (e.g., skills)

Anterograde Amnesia

- Inability to acquire new information (think of “memento”)
- Does not affect short-term memory
- Does not affect general knowledge from the past
- But, it is difficult to learn new facts
- Affects memory regardless of modality (visual, auditory, tactile, etc). Spares skilled performance
- Hyper-specific memory for those skills that are learned after onset – learning is expressed only in context in which it was encoded

Can amnesics acquire any new knowledge?

- Procedural memory (e.g., how to ride a bike) → yes
- Declarative memory (memory for information/knowledge, e.g. episodic & semantic memory) → impaired
- Implicit memories (using past information possibly without being aware of it) → yes
- Explicit memories (conscious recollection of events) → impaired
HM: Amnesic
- Mirror tracing task, Milner, 1965
- Improvement in H.M. for mirror tracing task
- No conscious recollection of previous training episodes

Learning to Miror-Reverse Read

<table>
<thead>
<tr>
<th>b</th>
<th>e</th>
<th>l</th>
<th>i</th>
<th>g</th>
<th>g</th>
<th>a</th>
<th>n</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td>o</td>
<td>l</td>
<td>o</td>
<td>v</td>
<td>e</td>
<td>d</td>
<td>r</td>
<td>e</td>
</tr>
<tr>
<td>s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>m</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>l</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Amnesics can learn to mirror-reverse read and are sensitive to repetitions

Spared (implicit) learning in anterograde amnesia

• Claparede study (1911).
  – Patient never remembered having met Claparede (doctor) before
  – Claparade offers handshakes with pinprick
  – Next time, no explicit memory of event (or doctor)
  – Still, patient refuses to shake hands and offers explanation: “sometimes pins are hidden in people’s hands”

• Korsakoff patients & Trivia questions

Amnesia involves failure of memory binding

• Recognition memory for pictures in Korsakoff patients and normal controls. Data from Huppert and Piercy (1976).