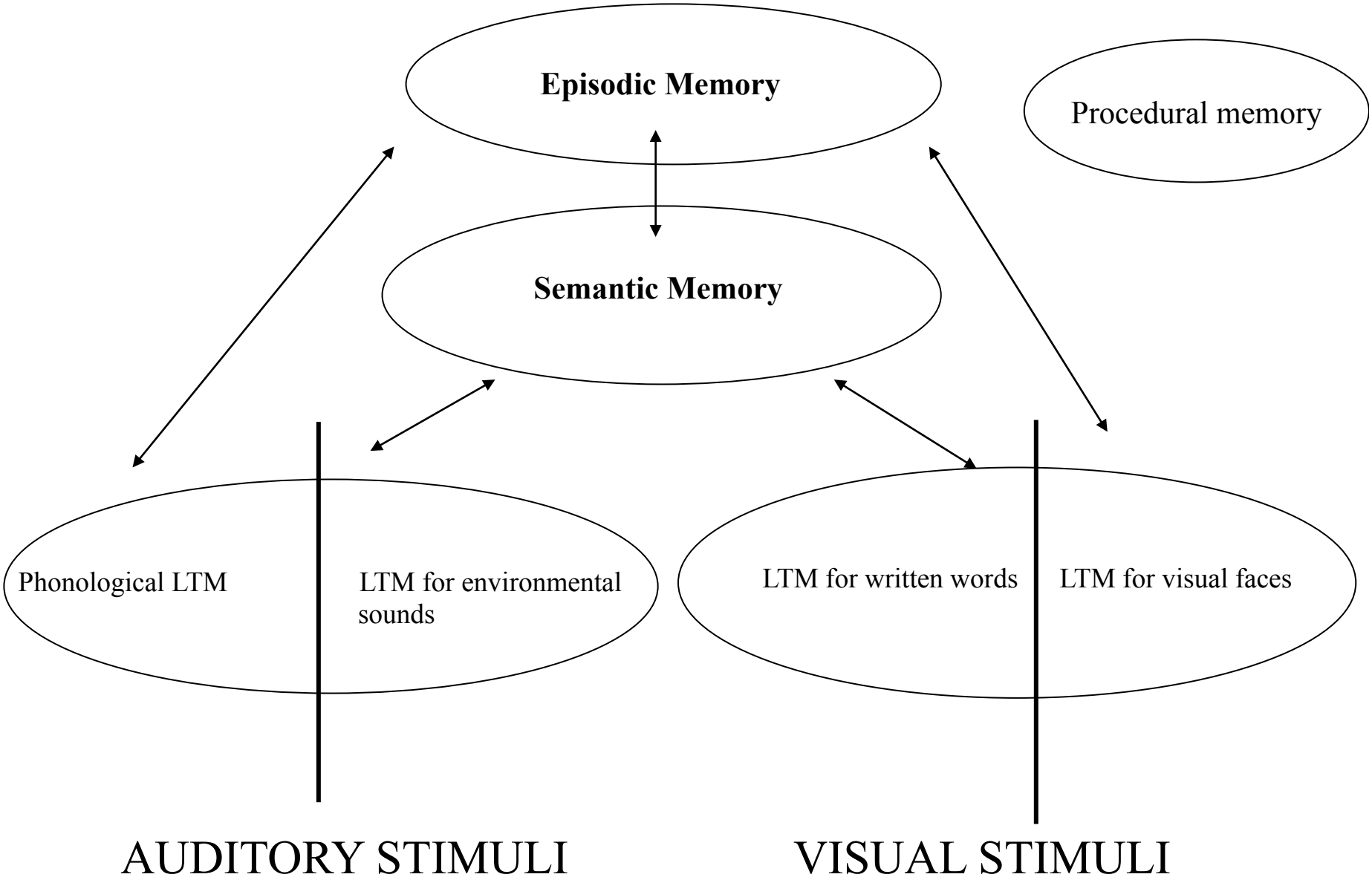
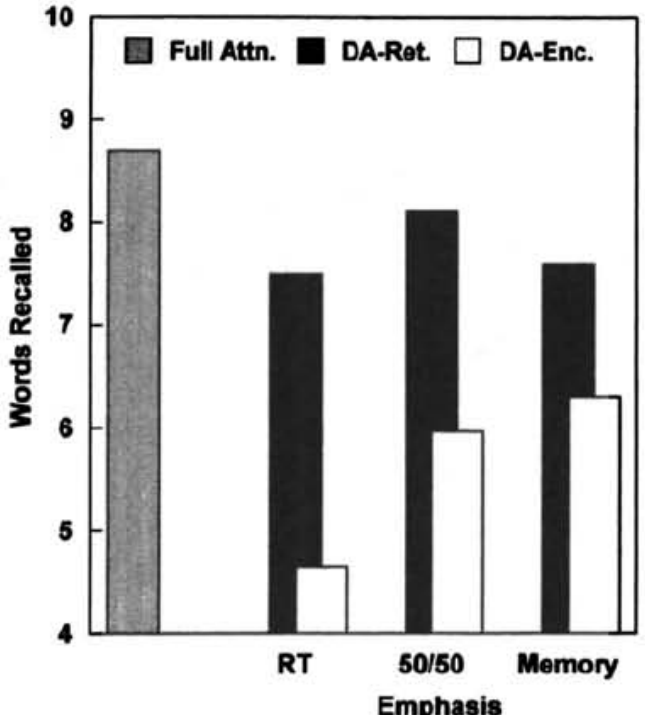
- Last class reviewed evidence that there are multiple different long-term memory systems.


Episodic Memory
Procedural memory
Semantic Memory
Phonological LTM
LTM for environmental sounds
LTM for written words
LTM for visual faces
AUDITORY STIMULI
VISUAL STIMULI

- In next two classes focus on the episodic memory system.
  - How is information encoded in episodic memory?
  - How is information stored in episodic memory?
    - Called consolidation
  - How is information retrieved in episodic memory
  - How/why episodic memory fails?

Encoding:

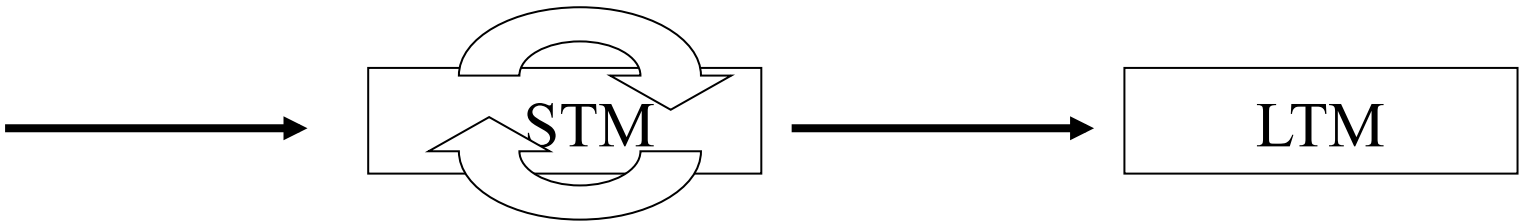
- In order to put things in episodic memory, must pay attention to events.
  - Craik, F.I.M., et al. (1996). The effects of divided attention on encoding and retrieval processes in human memory. *Journal of Experimental Psychology: General, 125*, 159-180.



-Participants studied word pairs (e.g., window-reason, fun-banana, etc.)
-At test, given the first item, attempt to recall the second.
-Dividing attention at encoding impacts on recall task (more than at recall)

Different ways to encode information (different ways to attend):

- **Maintenance rehearsal**: Keeping information active in STM by relying on phonological loop.
  - That is, just repeating information, without considering the meaning.
- Question: Does more rehearsal result in better episodic memory?



Time for an experiment!

- Instructions: Task is easy, just remember the last word that you hear that starts with the letter G. Ready?

–Non-verbal demonstration that repeated exposure to information is not enough to encode

(a) Actual coins now in use. (b) Modal coins constructed from recall data. From Rubin and Kontis (1983).

Rubin, D. C., & Kontis, T. C. (1983). A schema for common cents. *Memory & cognition*, *11*(4), 335-341.

Encoding into LTM...

- **Elaborative rehearsal**. Encoding the meaning of to-be-remembered information generally leads to better episodic memory.
  - Levels-of-processing: Memory is a by-product of perceptual and conceptual analyses.
    - Perceptual --> phonological --> conceptual.
  - Memory tends to be best for "deep" levels of encoding.
    - Intention to remember irrelevant.

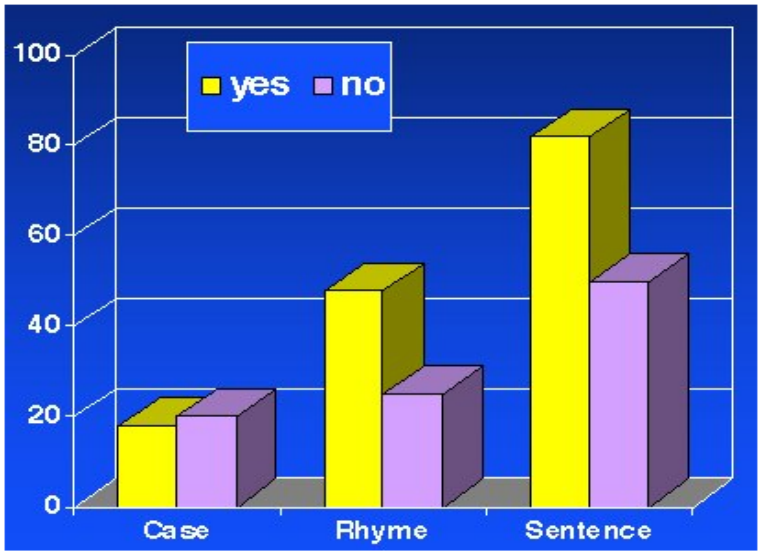
Levels of Processing:

Three encoding conditions:

case: Is the word in capital letters? TABLE

rhyme: Does the word rhyme with WEIGHT? CRATE

sentence: Does the word fit in the sentence:
"He met a _____ in the street?" FRIEND



Craik, F. I., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. *Journal of experimental Psychology: general*, *104*(3), 268-294.

Encoding Continued...

- Digit spans can improve using elaborative encoding. SF learned to recall over 80 digits!
  - Practiced 1 hour a day, 3 to 5 days a week, for more than 1.5 years
    - E.g., 3492 was recoded as "3 minutes and 49 point 2 seconds, near world-record mile time"
    - But memory not better for other types of materials
- Performance mediated by LTM, not STM (could remember lists from previous day)
  - » Ericsson, et al. (1980). Acquisition of a memory skill. *Science, 208,* 1181-1182.
- Memory for the position of chess pieces is much better in experts compared to novices
  - » Chase, W. G., & Ericsson, K. A. (1981). Skilled memory. *Cognitive skills and their acquisition*, 141-189.

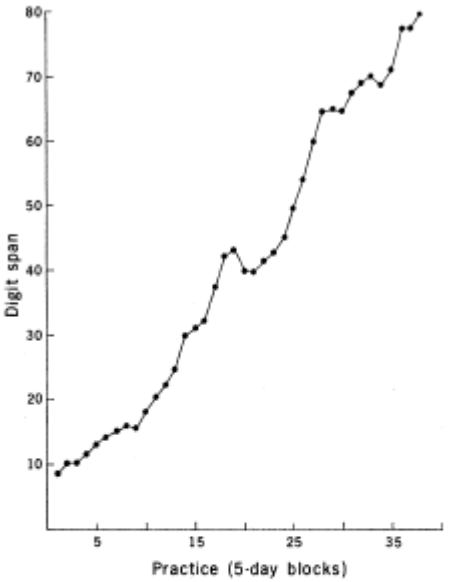


Fig. 1. Average digit span for S.F. as a function of practice. Digit span is defined as the length of the sequence that is correct 50 percent of the time; under the procedure followed, it is equivalent to average sequence length. Each day represents about 1 hour's practice and ranges from 55 trials per day in the beginning to 3 trials per day for the longest sequences. The 38 blocks of practice shown here represent about 190 hours of practice; interspersed among these practice sessions are approximately 40 hours of experimental sessions (not shown).

- Elaborative encoding best when organizing new new memories to fit with old memories.

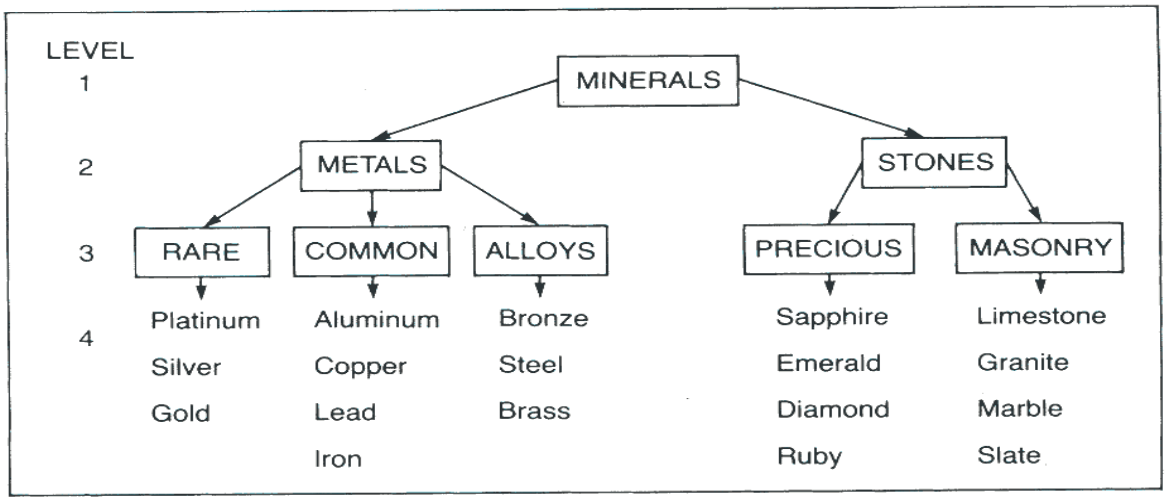


Figure 6-5

One of the hierarchies presented by Bower et al. (1969).

Table 6-5 AVERAGE PERCENTAGE OF WORDS RECALLED OVER FOUR TRIALS AS A FUNCTION OF ORGANIZATION

Conditions	1	2	3	4
Organized	65%	94.7%	100%	100%
Random	18.3	34.7	47.1	62.5

Adapted from Bower et al., 1969.

Bower, G. H., Clark, M. C., Lesgold, A. M., & Winzenz, D. (1969). Hierarchical retrieval schemes in recall of categorized word lists. *Journal of Verbal Learning and Verbal Behavior*, *8*(3), 323-343.

- Implication: what we encode is affected by our background knowledge, our interests, how we organize new information with old.
- As a consequence: people often remember quite different things
  - E.g., Museum example:

From: Schacter, D. L. (1997). *Searching for memory: The brain, the mind, and the past*. Basic Books.

Quotes:

- It's a painting with a smooth surface, an easy one to spot check. It is approximately five feet high and seven feet long.
- It has a film noir sort of feel, a mystery novel to it. The puzzle is there. You have all those little cues that will probably get you nowhere…. There is a face looking from the balcony, almost like a sun on the horizon. And when you look at her carefully, you realize that the towel probably conceals a decapitated head.
  - Which was spoken by a curator, a security guard?

- Picture Superiority Effect: We encode pictorial information better than verbal information.
  - Participants studied lists of pictures and words, and tested on pictures and words.
  - Asked to attend to the names at encoding (verbal instructions) or the image (imagery instruction).
  - Tested on pictures and words in Yes/No recognition task.

Measure	PP	PW	WP	WW
Verbal instructions (n = 56)				
Hits	.891	.846	.639	.607
Imagery instructions (n = 65)				
Hits	.892	.862	.805	.772

Note. The first letter of the trial-type designation represents the form of the study item and the second letter represents the form of the test item (P = picture; W = word). The –P and

Snodgrass, J. G., & McClure, P. (1975). Storage and retrieval properties of dual codes for pictures and words in recognition memory. *Journal of Experimental Psychology: Human Learning and Memory*, *1*(5), 521-527.

- Concreteness effect: Words like “car”, “house” better remembered than abstract words like “truth”, “betrayal”.

  Jessen, F., et al. (2000). The concreteness effect: Evidence for dual coding and context availability. *Brain and language*, *74*(1), 103-112.

- Together, these findings lend support to the “dual code theory”:
  - Information store information in at least two forms: verbal/linguistic code and a mental image code.

    Paivio, A. (1969). Mental imagery in associative learning and memory. *Psychological review*, *76*(3), 241-263.

Mnemonic devices

- Mnemonic devices improve memory by improving the encoding of information.
  - Deep levels of encoding, Organizing and linking new information to old, Visual imagery.
- Method of Loci: Imagine a journey through a familiar route:
    - e.g., bed, closet, bathroom, Bedroom 2, stairs, lounge, kitchen, front door, etc.
- Then take list of items you want to memorize and link them to the route through imagery.
    - corn, potatoes, bread, flour, OJ, milk, coffee, etc.

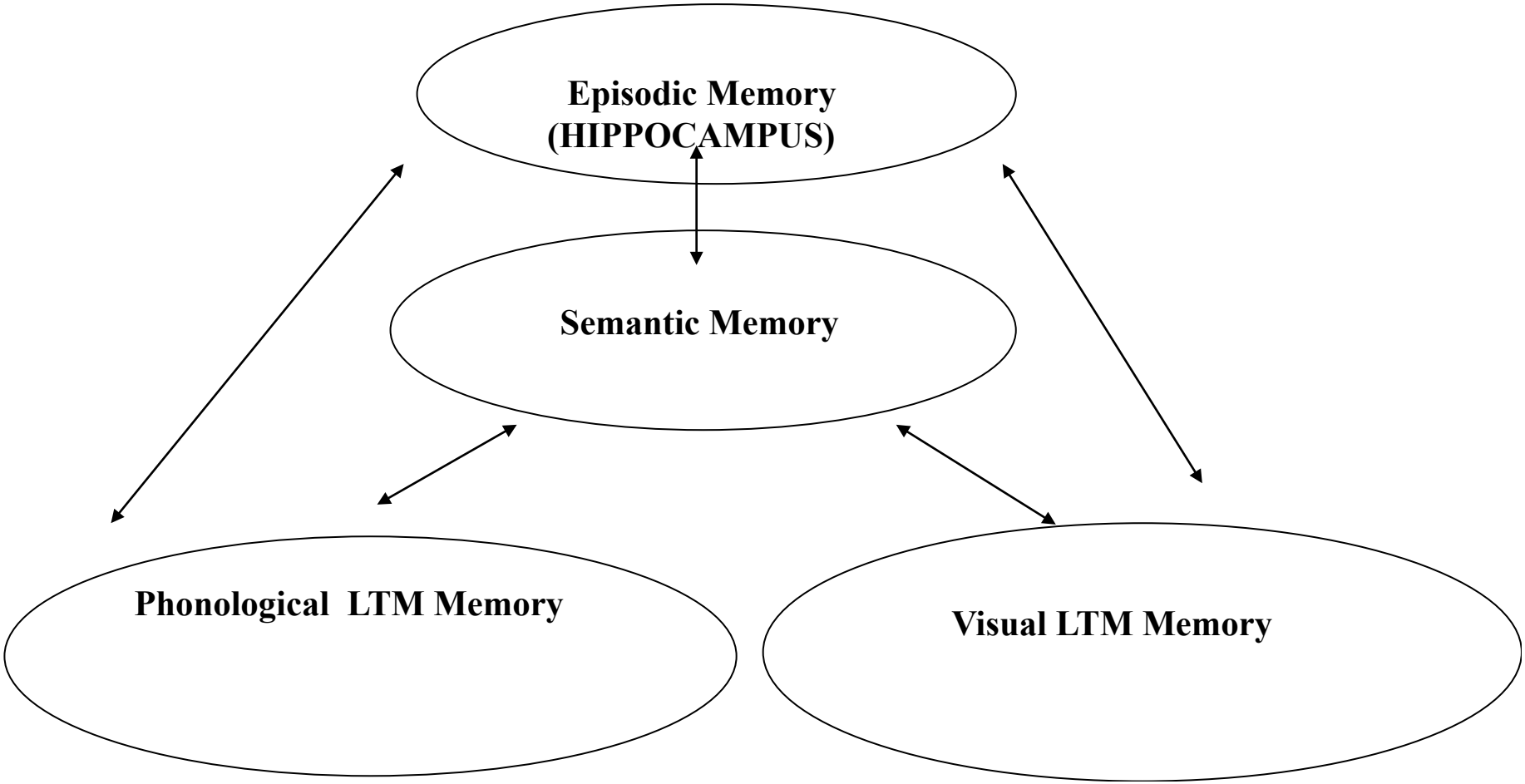
Encoding….

- Encoding can’t be the complete story because amnesic patients encode to deep levels and still can’t remember
  - so something else in addition: Consolidation (storage).

Consolidation (storage)

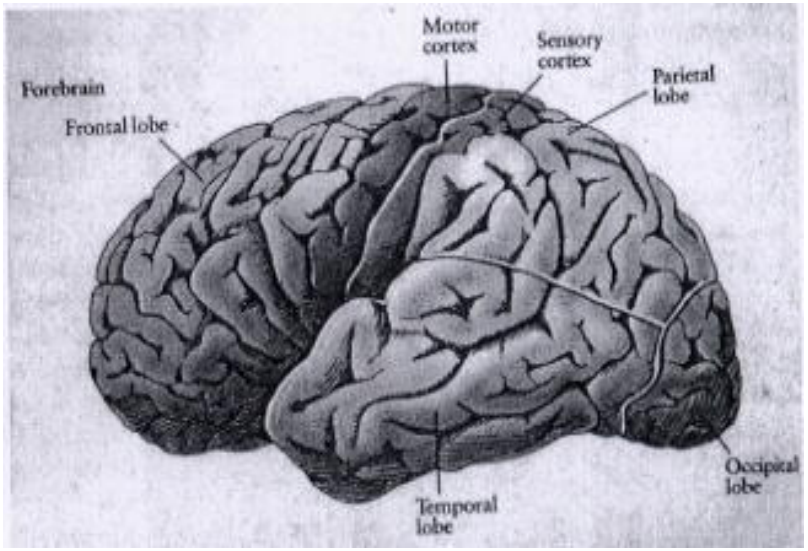
- Definition: the process of converting memories into a format resistant to forgetting.
  - Two types (short-term & long-term consolidation)
- Short-term consolidation: converting short-term memories into it more enduring format. Occurs over seconds or minutes.
  - Short-term consolidation involves the hippocampus linking information from all the various LTM systems via the hippocampus to form an episodic memory.

- Short-term consolidation: Takes seconds/minutes to develop long-term links from hippocampus to other memory systems.



Consolidation...

- Consolidation within hippocampus. Binds information across different systems located in different parts of the cortex.

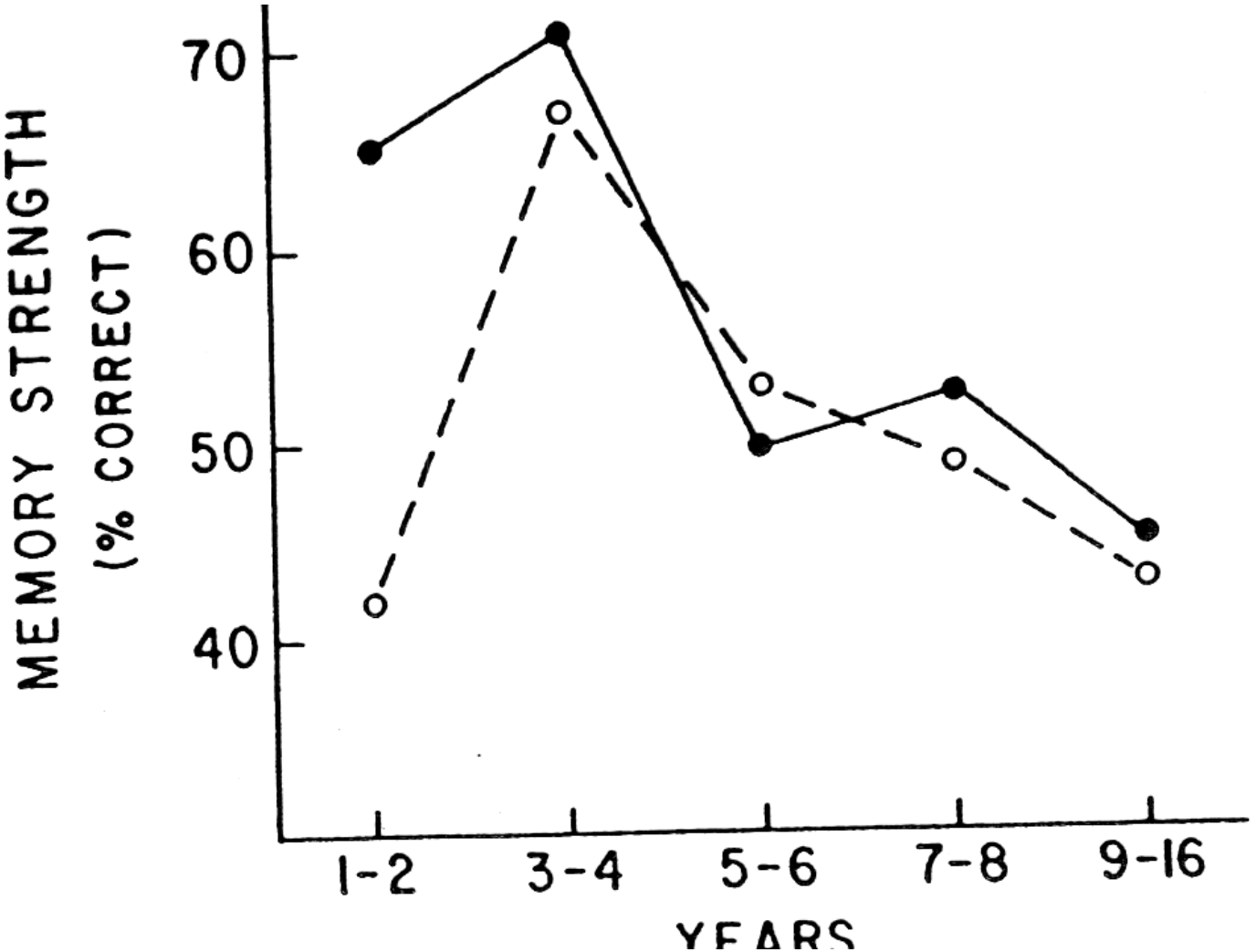


- Evidence: Brain trauma erases memories encoded seconds or minutes before trauma (short-term retrograde amnesia).
- US college football injury study.
  - Experimenters went and tested memory of US football players shortly after they were knocked out for a few seconds.
  - No memory of last play, and never recover seconds-minutes prior to hit.
    - » Yarnell, P. R., & Lynch, S. (1973). The" ding": Amnestic states in football trauma. *Neurology, 23,* 196-197.

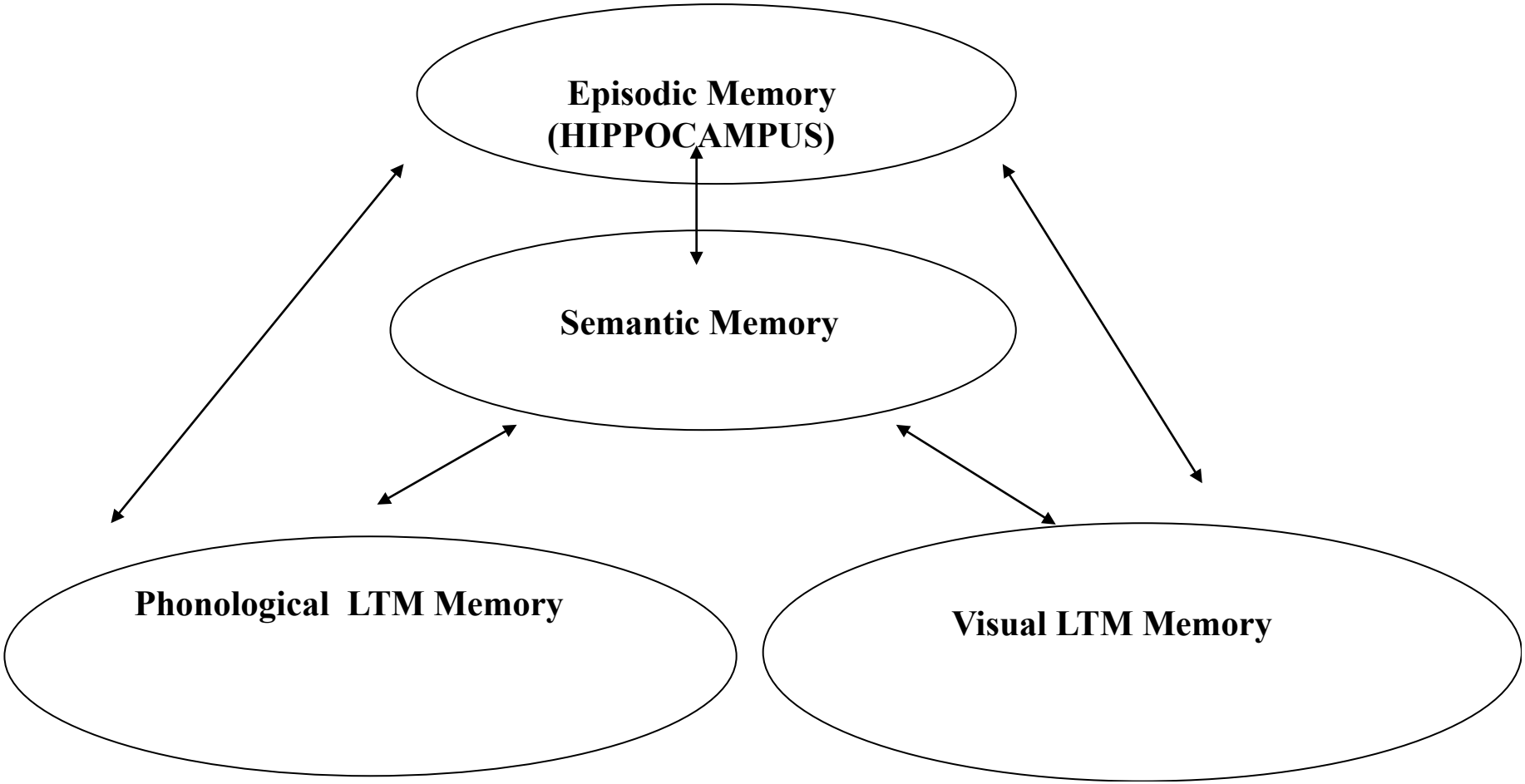
Long-term Consolidation

- Long-term consolidation that occurs over months, years. Observed in retrograde amnesia.
  - HM's surgery 1953. Some loss till 1942
    - » Corkin, S. (2002). What's new with the amnesic patient HM?. *Nature Reviews Neuroscience*, *3*(2), 153-160.
  - Relative sparing of older memories following ECT – retrograde amnesia extends years.
    - » Squire, L. R., Slater, P. C., & Chace, P. M. (1975). Retrograde amnesia: Temporal gradient in very long-term memory following electroconvulsive therapy. *Science*, *187*(4171), 77-79.

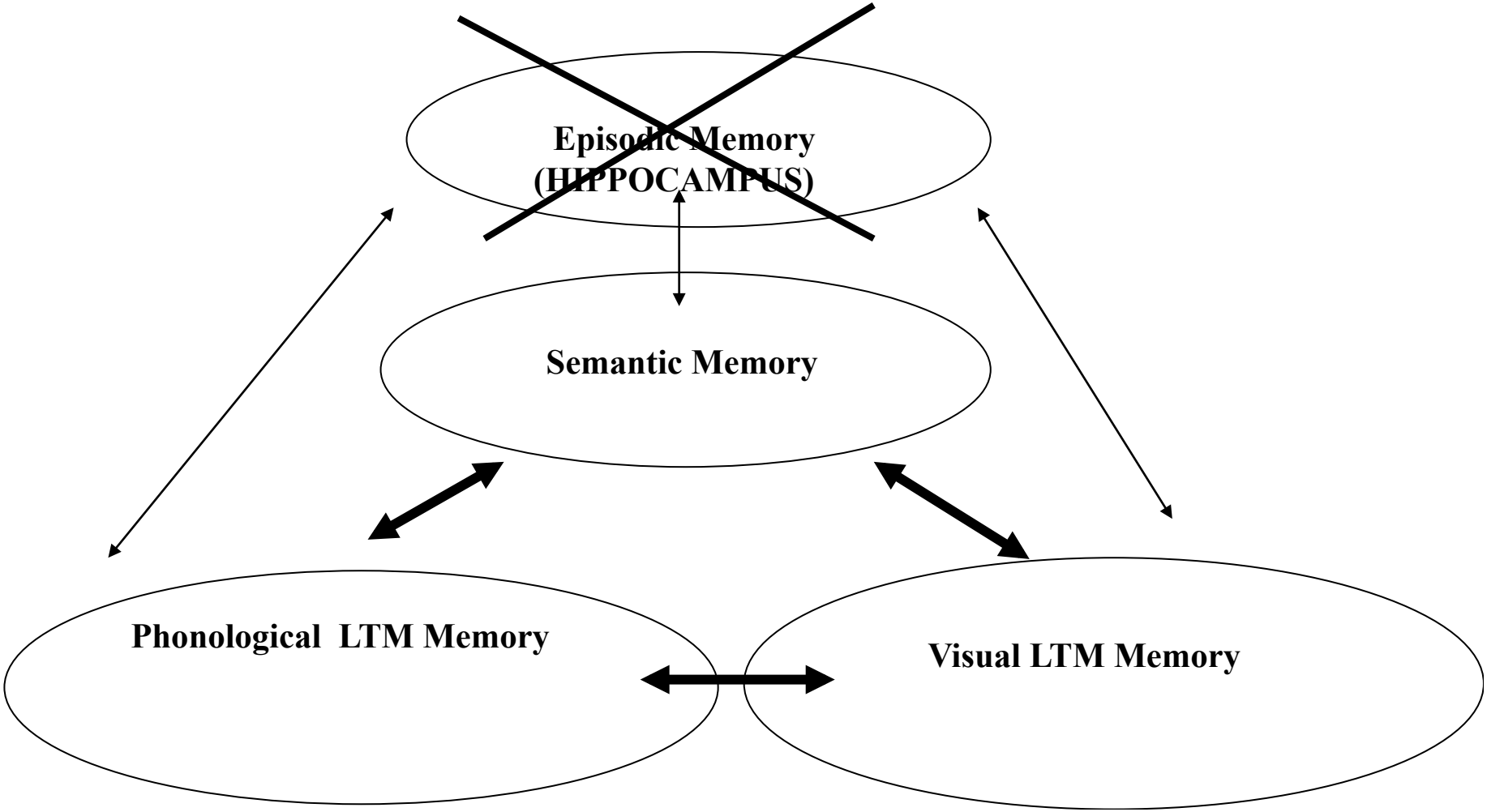
Memory for TV shows following ECT



- Hypothesis: Initially (due to short-term consolidation), memory in hippocampus links all the various types of LTM in order to store a record of the episode.



- Over time, memories in the various LTM systems are linked directly (without requiring the hippocampus) to form an episodic memory.

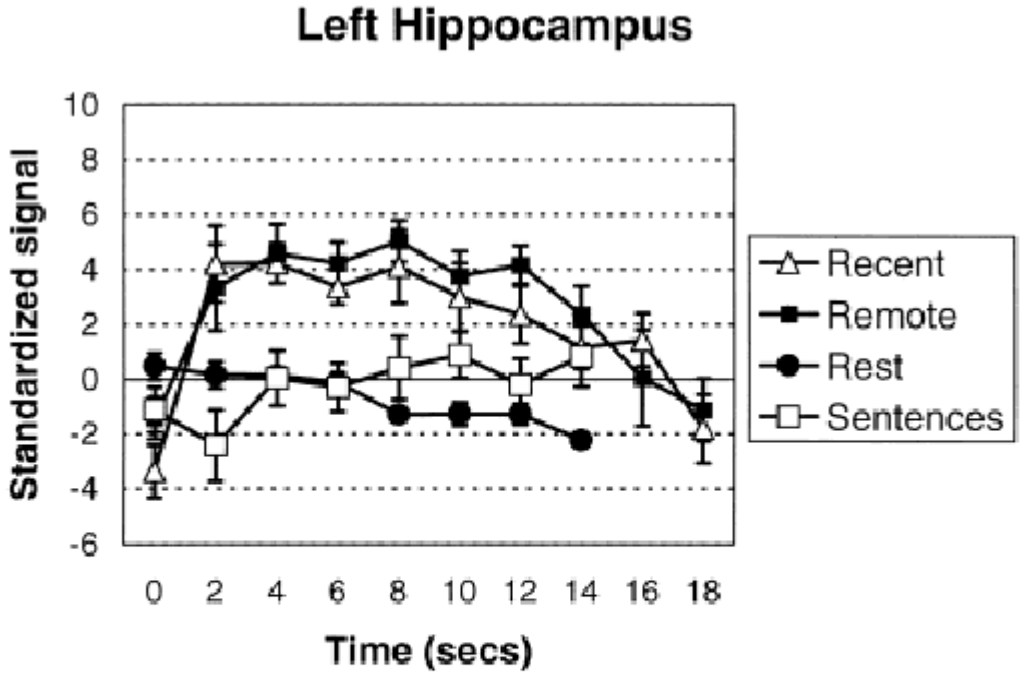


- On this view, damage to hippocampus does not erase old episodic memories because they have moved to cortex.
  - For detailed discussion, see:
    - » McClelland, J. L., et al. (1995). Why there are complementary learning systems in the hippocampus and neocortex: insights from the successes and failures of connectionist models of learning and memory. *Psychological Review*, *102*(3), 419.

- On another view, older memories are better coded within the hippocampus because they have been rehearsed more often. The so-called "multiple-memory trace" (MMT) hypothesis.
  - Episodic memories always rely on the hippocampus, and do not move to the cortex.
  - This view denies that episodic memory undergoes long-term consolidation.

» Nadel, L. & Moscovitch, M. (2001). *Trends in Cognitive Neuroscience, 5,* 228-230.

- According to MMT hypothesis the hippocampus is always involved episodic memories, and the severity and extent of RA depends on the extent of the hippocampal lesion.
- Prediction: hippocampus should be involved in the retrieval of old and recent episodic memories.
  - Subjects asked to remember for 20s a number of old memories (e.g., learning to drive), and recent memories (e.g., recent vacation) while FMRI is carried out.



(semantic retrieval)

FIGURE 1. Mean (SEM) activation in left hippocampus over a 20-s time period for four conditions: recollection of recent events, recollection of remote events, sentence completion, and a rest period. Data are averaged across six subjects showing activity in the right hippocampal region. Sagittal section shows center of activation (X) for each of the six subjects.

***The fact that hippocampus more involved in memory compared to sentence condition suggests hippocampus involved in episodic memory, not simply the retrieval of meaningful information.

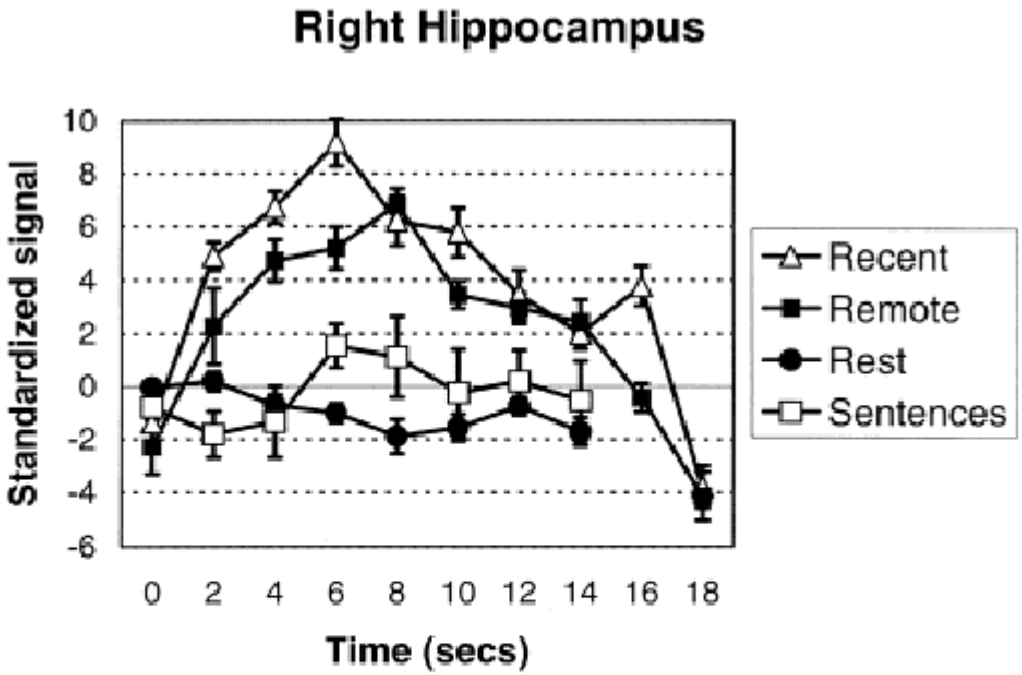


FIGURE 2. Mean (SEM) activation in right hippocampus over a 20-s time period for four conditions: recollection of recent events, recollection of remote events, sentence completion, and a rest period. Data are averaged across six subjects showing activity in the left hippocampal region. Sagittal section shows center of activation (X) for each of the six subjects.

From: Ryan, L, et al. (2001). Hippocampal complex and retrieval of recent and very remote autobiographical memories: evidence from functional magnetic resonance imaging in neurologically intact people. *Hippocampus*, *11*(6), 707-714.

- This data suggest that the hippocampus is always involved in retrieving memories, even very old ones.
  - This contradicts a strong version of long-term consolidation in which the memories move from hippocampus to cortex, and that they are no longer in hippocampus.

- Further testing long-term consolidation and MMT hypothesis:
  - Alzheimer's Disease is associated with lesions to the hippocampus, and extensive retrograde is commonly associated with this disease.
  - Imagine you ask an old person suffering from Alzheimer's Disease to name their parents, children, siblings, and remember episodes with these persons.
  - On the long-term consolidation hypothesis, who would be forgotten first?
  - On MMT hypothesis, who would be forgotten first?