The California State University
WORKING FOR CALIFORNIA

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COGNITION

Kellogg Chapter 4
Memory Systems

Fund. of Cognitive Psychology (2nd) *(Kellogg)*

No one is likely to remember what is entirely uninteresting to him.

- George MacDonald

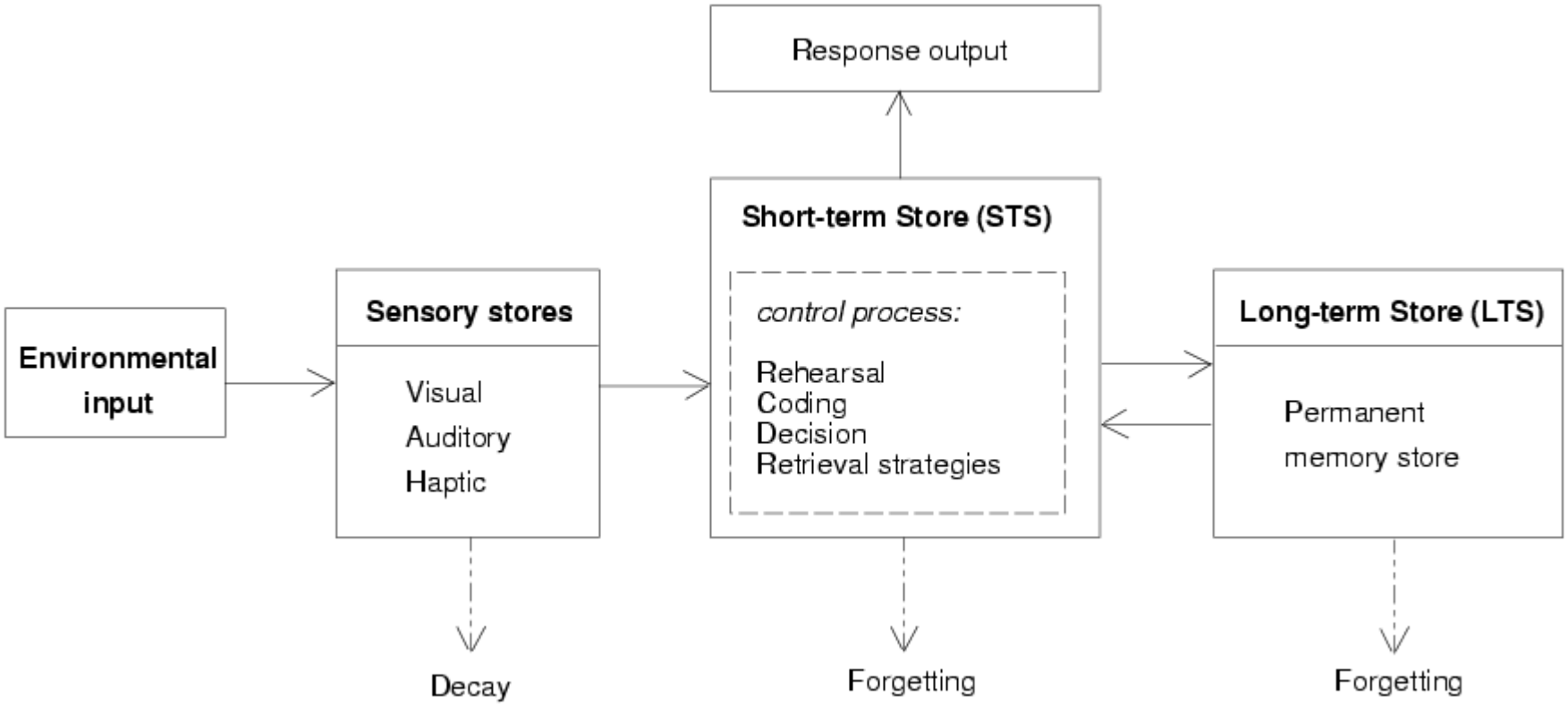
Memory

Memory is the means by which we retain and draw on our past experiences to use that information in the present.

As a process, memory includes the dynamic mechanisms associated with storing, retaining, and retrieving information about past experiences

Memory involves ENCODING, STORAGE, & RETRIEVAL

Atkinson & Shiffrin (1968) "Standard Model of Memory"



THREE BASIC STORES: SENSORY, SHORT-TERM, and LONG-TERM

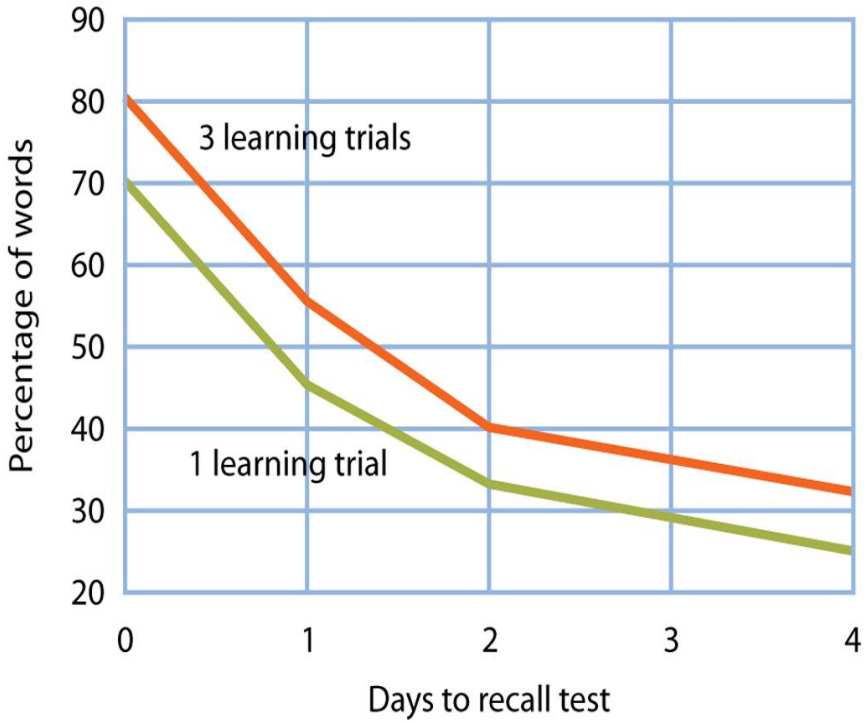
Schacter's Seven Sins of Memory (p.94)

- Transience
  - rapid loss of information from STM (no LTM transfer)
- Absent-mindedness
  - Breakdowns in attention (no encoding into STM)
- Blocking
  - Inability to retrieve information from LTM
- Misattribution
  - Source misattribution is misidentifying source of knowledge
- Suggestibility
  - Susceptibility of memory to incorporate misinformation
- Bias
  - Our current beliefs influence our perception of the past
- Persistence
  - An unwelcome imposition of past memories (e.g., PTSD)

Seven Sins of Memory

Sins of Omission

- Transience
  - Decay
  - Forgetting curve
- Absent-mindedness
  - Divided attention
- Blocking
  - Repression
  - Recovered memory



Seven Sins of Memory

Sins of Omission

- Transience
- Absent-mindedness
- Blocking

Sins of Commission

- Misattribution (Source)
- Bias (Consistency/Belief)
- Persistence
- Suggestibility
  - False memory (leading questions)

Memory (History)

Hermann Ebbinghaus (1850-1909) studied higher mental processes. Ebbinghaus used the study of nonsense syllables to discover the fundamental laws of learning and developed the forgetting curve based on his “method of savings.”

George Miller is best known for his studies on the capacity of Short-term Memory (STM). His name is associated with the "Magic Number 7 plus/minus 2” (bits of information in STM) and “chunking.”

Frederick Bartlett studied memory under natural conditions. He posited that past experience helps reconstruct the material sought to be retrieved. He saw memory as an active and often inaccurate process (“omissions” and “normalizations” – later expanded upon by Kintch).

George Sperling (1960) used partial and whole report to study “Iconic Memory”

Averbach & Coriell (1961) studied “Iconic Memory” (and masking)

Baddeley advocated for a conceptualization of active “working memory” over the prior passive conceptualization of STM.

Sensory Memory

Brief persistence following transduction

Perceptual systems operate on sensory information to create perceptions.

Not all incoming information can be processed due to limited higher level system capacity. Information that is not immediately attended to is available in a very temporary "buffer" (sensory memory), allowing some later processing – as when you can still hear someone asking you a question even though you weren't really listening when they asked it.

There is a separate sensory buffer for each sense.

Iconic Memory (vision)

- Capacity: Essentially that of the visual system (Sperling)
- Duration: About 250 milliseconds seconds (Sperling)
- Processing: None additional beyond raw perceptual processing

Echoic Memory (hearing}

- Capacity: ????
- Duration: About 2 seconds (but often appears longer with contribution of STM coding)
- Processing: None additional beyond raw perceptual processing

Iconic Memory

The iconic store in vision is a discrete visual sensory register that holds more information than can be transferred to STM before the information decays.

- Writing your name with a sparkler leaves no physical trace but the residual activation of the sensory store allows you so “see” your name.

George Sperling (1960) used “partial-report” (a tone cue) vs. “whole-report” to illustrate that the contents of the visual sensory register (iconic memory) was greater than that indicated by whole report procedures (which depend on transfer to STM). When the cue was simultaneous with (or preceded) the stimulus, performance was well above whole-report levels, but declined to a cue-lag of approximately 1 second before approximating whole-report accuracy levels.

Sperling (Iconic Memory)

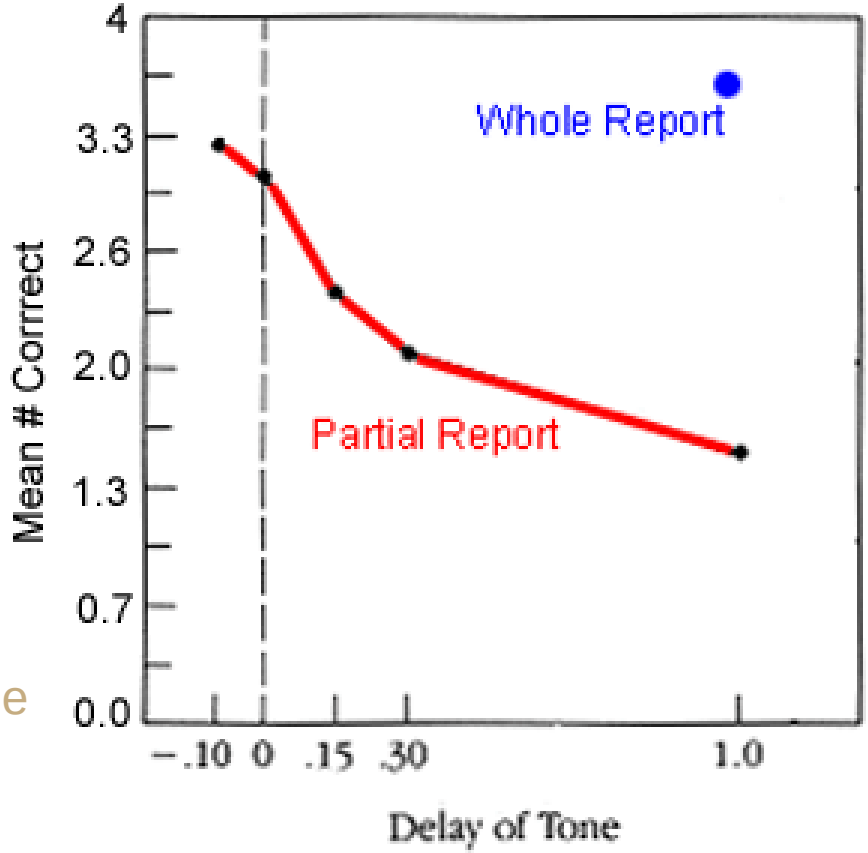
Tachistoscopic presentation (50 ms, no mask)

M	G	K	J
B	L	F	N
X	P	T	O

Whole Report = report all

Partial Report = report cued line (tone)

"with 200 to 300 ms, the number of letters available dropped to 4 or 5 – the same number available in the whole report condition" → the duration of iconic memory is approximately 250 ms

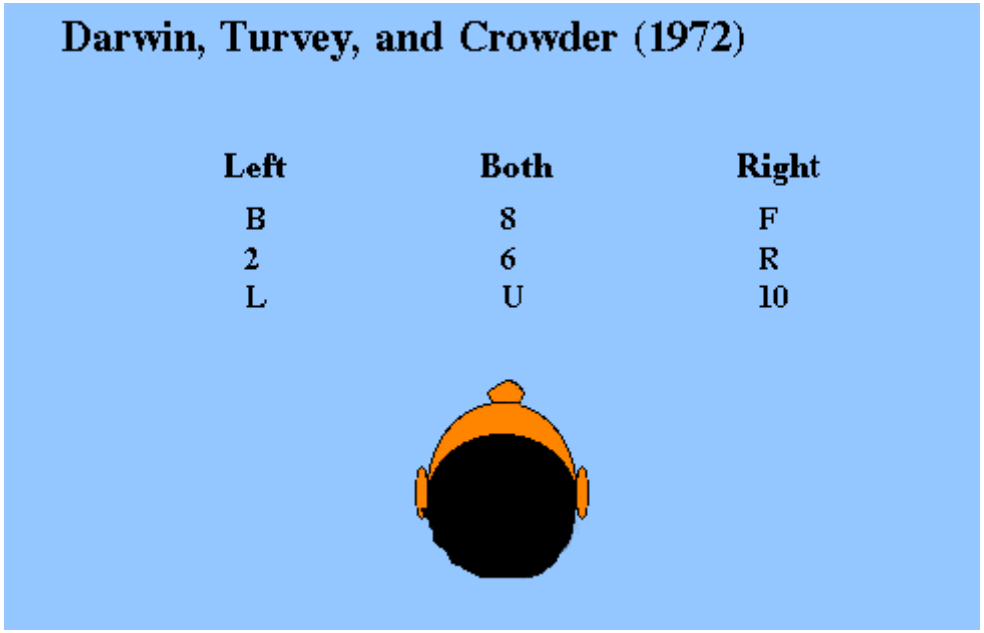


Moray (Echoic Memory)

Moray, Neville (1959). "Attention in dichotic listening: Affective cues and the influence of instructions"

"Third Ear" procedure

- Right
- Left
- "Middle"



Stimulus Presentation and Cueing analogous to Sperling (1963)… but with auditory (vs. visual) stimuli

Echoic Memory

Interpreting the work of Neisser (and others), Cowan (1988) argues that the duration of “pure” echoic memory is approximately the same as iconic memory (c. 250 ms) but it can be buttressed by short term memory (e.g., by recoding into speech, etc.) yielding the more widely received estimate of 2+ seconds duration (Kellogg, p.99).

Cowan, N. (1988)

"The resulting estimate for adults is two or three items… perhaps the number of activated memory items is limited to about seven, whereas the subset of these items in awareness and voluntary attention is limited to two or three……" (Cowan, p.166).

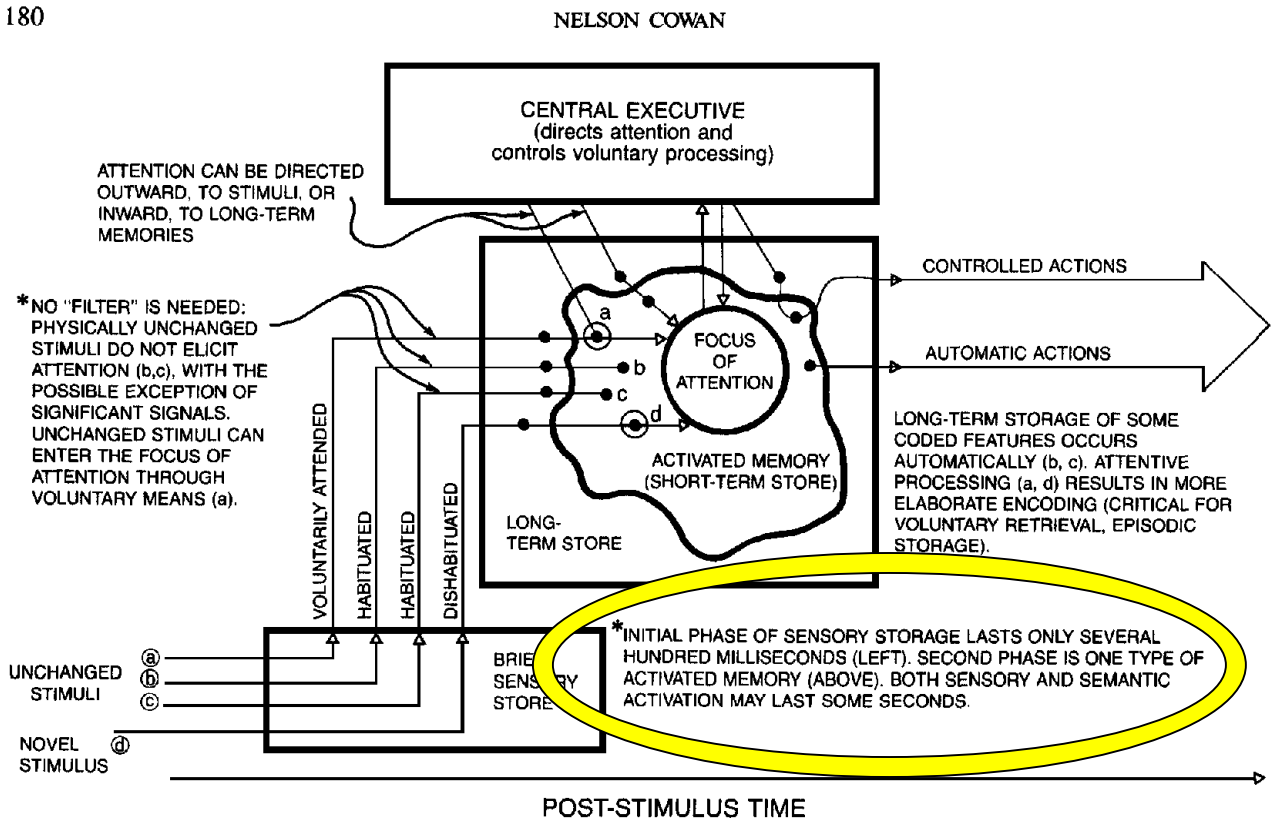


Figure 1. A revised model of the information-processing system. The time since stimulus reception is represented ordinally along the *x* axis. The components are arranged in real time, and stimulus information can be present in more than one component at the same time. Short-term storage is represented as an activated subset of long-term storage, and the focus of attention is represented as a subset of short-term storage. Habituated stimuli do not enter the focus of attention. The timing of involvement of the central executive in processing is flexible. The arrows represent the transfer of information from one form to another; these are discrete approximations to continuous processes that can occur in parallel or cascade. Pathways leading to awareness can come from three sources: changed stimuli for which there is dishabituation, items selected through effortful processing (whether of sensory origin or not), and the spontaneous activation of long-term memory information based on associations (not shown).

Cowan, N. (1988). Evolving conceptions of memory storage, selective attention, and their mutual constraints within the human information processing system. Psychological Bulletin, 104, 163-191

"Working Memory"

Working Memory conveys active information processing, STM does not.

working memory holds content that you are generally conscious of and can work with.

Capacity: About 7 plus or minus 2 "chunks" of information (Miller, 1956 – "*The Magical Number Seven, Plus or Minus Two*.")

- Miller defined a "chunk" as an independent item of information -- one whose recall did not aid in the further recall of the other items. Random letters such as "G,J,K" would each be considered a chunk, but letters that form a recognizable larger whole, such as "C,A,R" would not. (In this case the word "car" is a single chunk.)
- recent papers have argued for a "real" STM capacity of 5 or fewer items – Lee and Chun (2001) illustrate a visual change detection limit of four visual objects

Duration: About 18 to 20 seconds (Peterson & Peterson, 1959)

- Information that enters STM fades away, or *decays* as soon as it is no longer attended to. (The duration of 18-20 seconds assumes that the information is not being actively rehearsed.) Information that is being actively attended to is represented by a pattern of neural activity in the brain may become represented more permanently by guiding changes in neural connectivity in the brain, a process referred to as *storage*. But information that is not more permanently stored is simply lost shortly after attention is directed elsewhere.

Coding: typically stored verbally (phonologic errors in letter recall); dual-coding hypothesis holds visual + verbal codes produce best LTM storage; semantic codes also used (Wickens, etc.)

Processing: There are severe limits on the amount of information able to be held in mind simultaneously, producing an information processing *bottleneck*.

Long-term Memory (LTM)

LTM is the relatively permanent memory store in which you hold information even when you are no longer attending to it. Information held in LTM is not represented as patterns of neural activity (as in STM), but rather as changes in brain wiring -- in the "conductivity" of existing synapses, and in the formation new synapses and destruction of old ones. Storing information in LTM is equivalent to a computer writing information out to its hard drive, or to a tape recorder writing patterns of magnetization onto tape to record music. The recording process is called **storage** and the "playback" process, **retrieval**.

Capacity: Virtually unlimited

Duration: Up to a lifetime

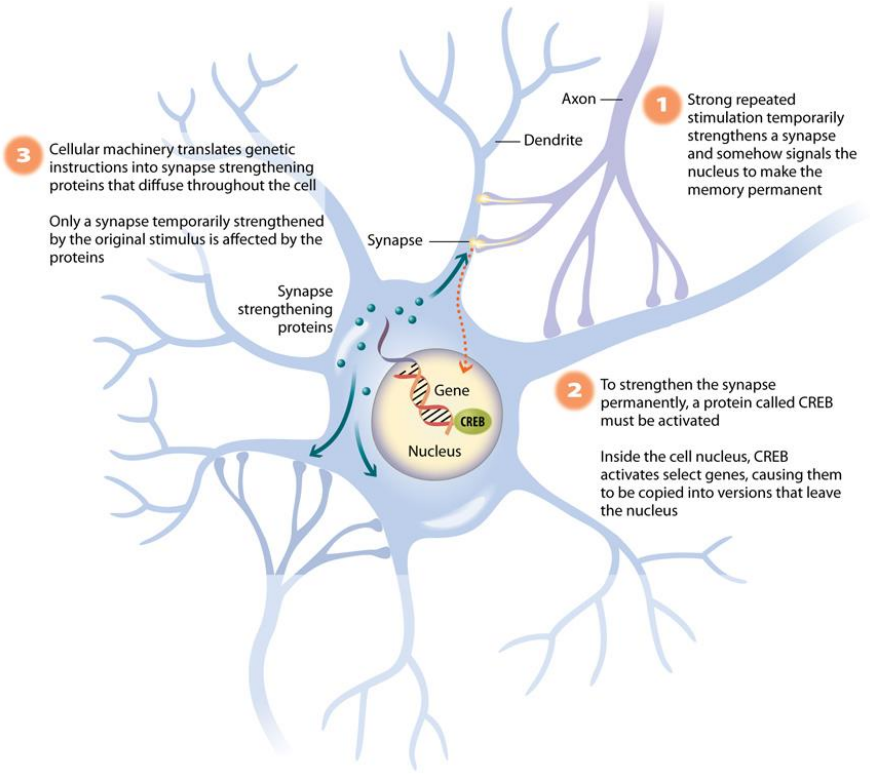
Coding: dual-coding hypothesis holds visual + verbal codes produce best LTM storage

Processing: Information is organized according to *meaning* and is associatively linked

How Practice Makes Perfect

Per *Eric Kandel*

- Conversion from short-term to long-term memory storage requires spaced repetition
  - *CREB*



Long Term Memory

If you cannot remember something you once knew, is it because it has been lost from the system, or because you have developed a problem locating it for retrieval?

Permanent losses do occur as a result of brain damage, and it is possible that some memories simply decay away if they are not accessed for a very long time. We do know with certainty, however, that some failures of retrieval are due to temporary blockages and not to the loss of the information in memory. You may be unable to remember someone's name at present, for example, but later it comes to you. Obviously, it was there in memory all the while.

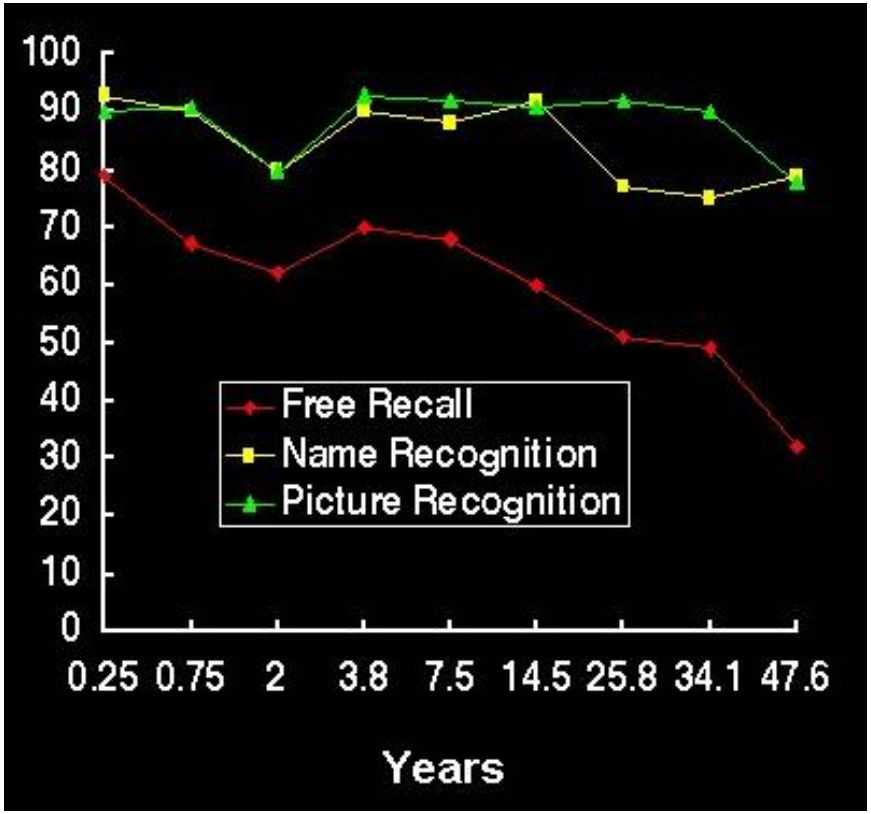
A common idea is that everything we have ever experienced has created a long-term memory, but this is unlikely to be so.

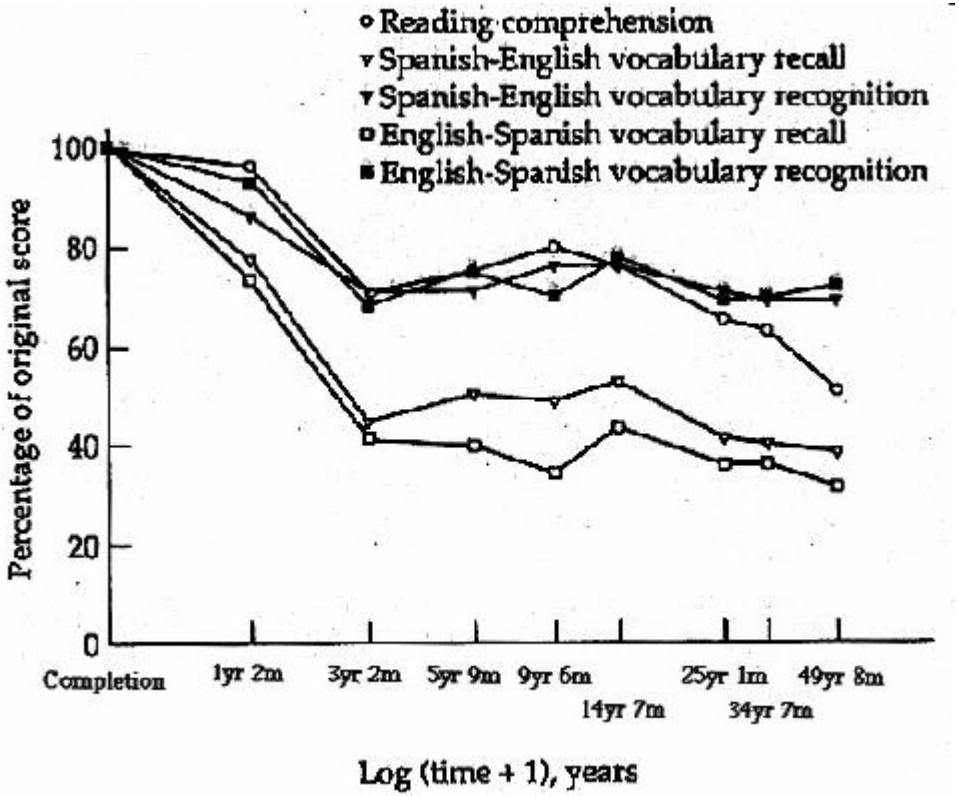
Much of what we experience is never attended to, or not attended to beyond a few brief moments, and probably does not result in activation of the storage process.

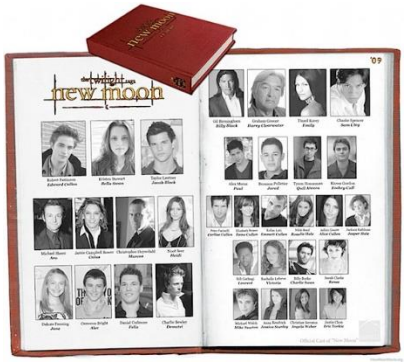
LTM encoding involves a rather slow process requiring many hours to complete, called **consolidation**.

If an individual is rendered unconscious (as in an accident), memories just beginning to consolidate at that time may not form. Of course, STM involves no such extended consolidation process.

Bahrick, H. P.; Bahrick, P. O.; Wittlinger, R. P. (1975). Fifty years of memory for names and faces: A cross-sectional approach. Journal of Experimental Psychology: General, 104(1), 54-75. doi: 10.1037/0096-3445.104.1.54







Bahrick (1984): Spanish Vocabulary

Impaired Short-Term Memory

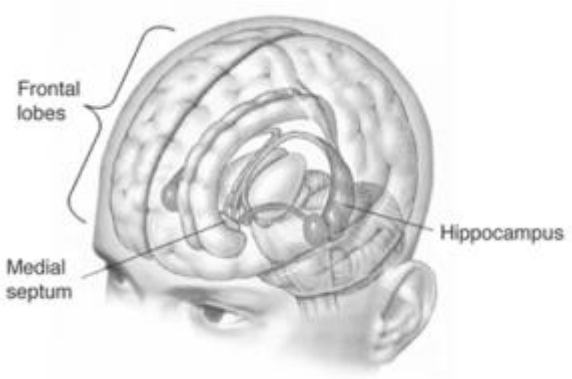
Warrington & Shallice report patient “K.F.”

- KF could report only a single letter after a 60 second post-presentation delay
- This deficit was even stronger for auditory presentation – a mere two spoken letters were enough to be rapidly forgotten.

Comparing the deficits of patients HM & KF illustrate the separation of STM and LTM processes.

Amnesia

- The abnormal loss of material from LTM or the failure to transfer it from STM to LTM.
- A loss that one cannot attribute to the normal process of forgetting (e.g., brain injury)
- Psychogenic causes are VERY rare
- Hippocampal systems are implicated in the storage of events into LTM (e.g., H.M.) (esp. in the indexing and binding of event features – as evidenced by the dissociation between encoding/consolidation and retrieval).



Amnesia

Retrograde Amnesia - loss of memory for events PRIOR TO brain injury (loss is backwards in time).

- Concussions generally produce a few minutes of confusion. After this confusion disappears they may find that they cannot recall any of the five or ten minutes leading up to the blow on the head. Normal memory storage was interrupted by the abnormal patterns of neural firing triggered by the concussion.
- ***Ribot's Law*** (a.k.a, "***temporal gradient"*** or the "***first-in, last-out principle***") suggests that memory loss is most severe for the events just prior to the trauma and decreases systematically the further back in time (minutes, months, or years) from when the event occurred.

Anterograde Amnesia - loss of memory for events occurring AFTER the trauma.

- Not all amnesia patients display noticeable retrograde amnesia beyond the few minutes leading up to the concussion. All suffer from memory loss for things that happen after the trauma. STM is still available, but the ability to transfer information to LTM is badly impaired.
- Another way to view anterograde amnesia is as a deficit in learning; one cannot remember that which has not been learned. **Ribot's law** does not apply to anterograde amnesia.
- Some amnesias (especially Korsakoff's syndrome [Alcohol abuse and B1 deficiency]) involve are almost entirely confined to anterograde symptoms.

Childhood "Amnesia" (a.k.a., infantile amnesia)

- One theory is that the information is stored but is not retrievable (i.e., the maturing operating system is not backwards compatible)
  - [retrieval failure hypothesis]

- A second theory is that the events were never adequately encoded (e.g., the lack of 'self' identity or lack of language could prevent episodic memory)
  - [consolidation failure hypothesis]

Human Memory Characteristics

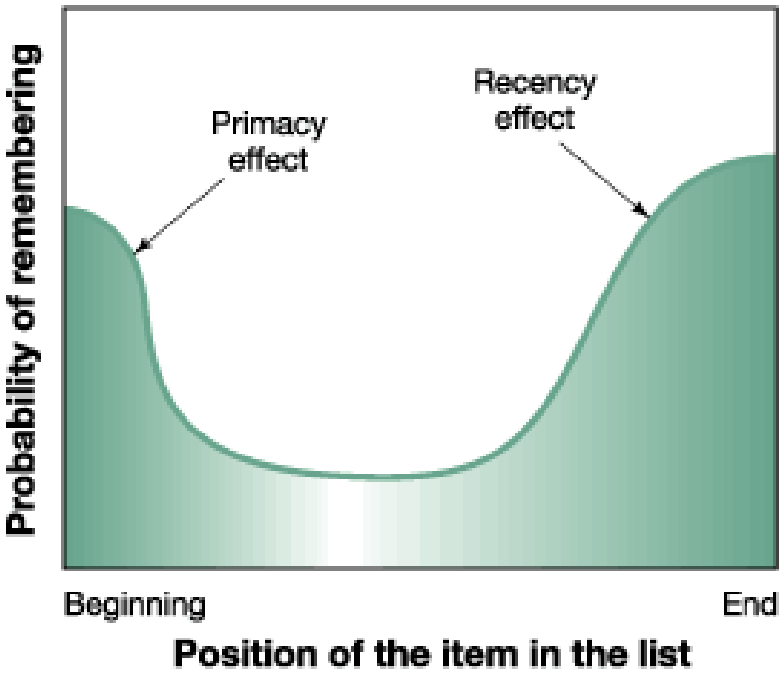
Serial Position Effects

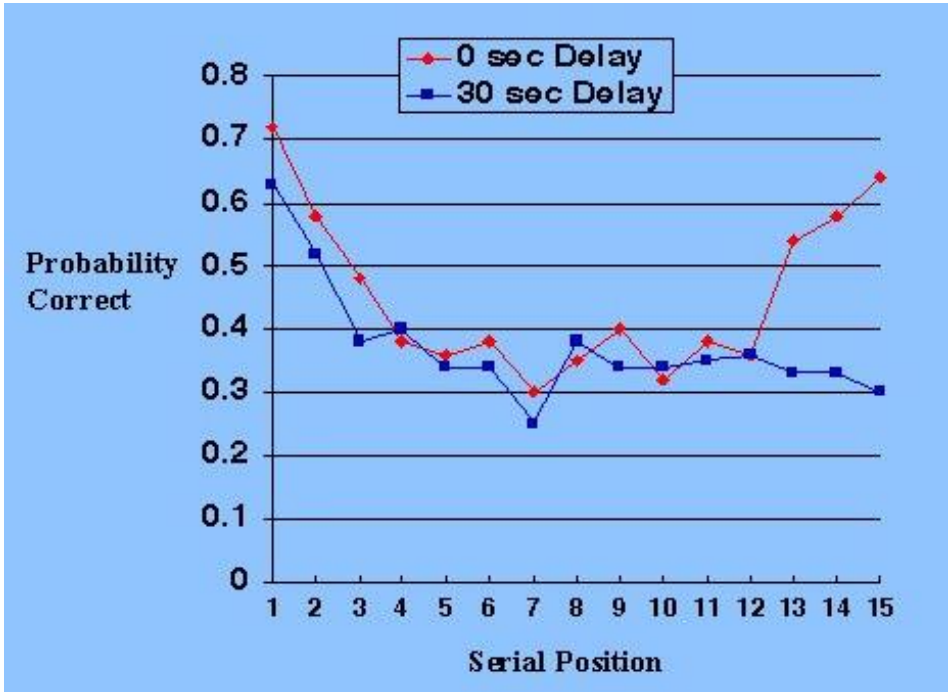
- “Pet” example (in class)
- Words example (p. 99)

Limited Capacity of STM

- Digit-Span (p.106) [Miller, 1956] / Chunking (grouping meaningful information together)

Serial Position Curve





Early items are remembered better (Primacy Effect, due to LTM encoding)

Last items are remembered better (Recency Effect, due to STM activation)

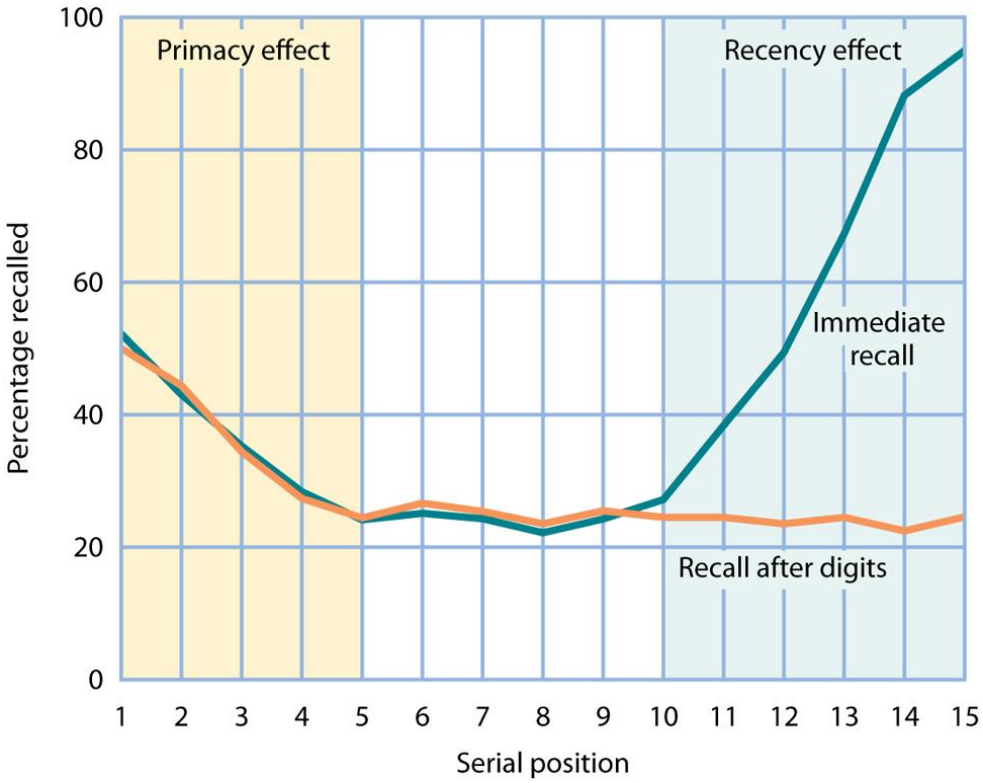
Primacy effects can be reduced by speeding through the items (no rehearsal [Rundus])

Recency effects can be reduced by delaying recall.

Serial Position Effects in Memory

Serial position effect

- Primacy effect (LTM)
- Recency effect (STM)



Loss of Information from STM (Interference versus Decay)

Interference: a general explanation of forgetting. Information competes with or disrupts memory

Decay: Fading or Forgetting of information across time due to the passage of time.

Loss of Information from STM (Interference versus Decay)

Brown-Peterson Task

- present string of three letters for participant to remember

  { M X J }

- present base number for participant to start counting backwards by threes

  { 237 }

- wait set amount of time (3-18 seconds) before participant is to recall the original three letters

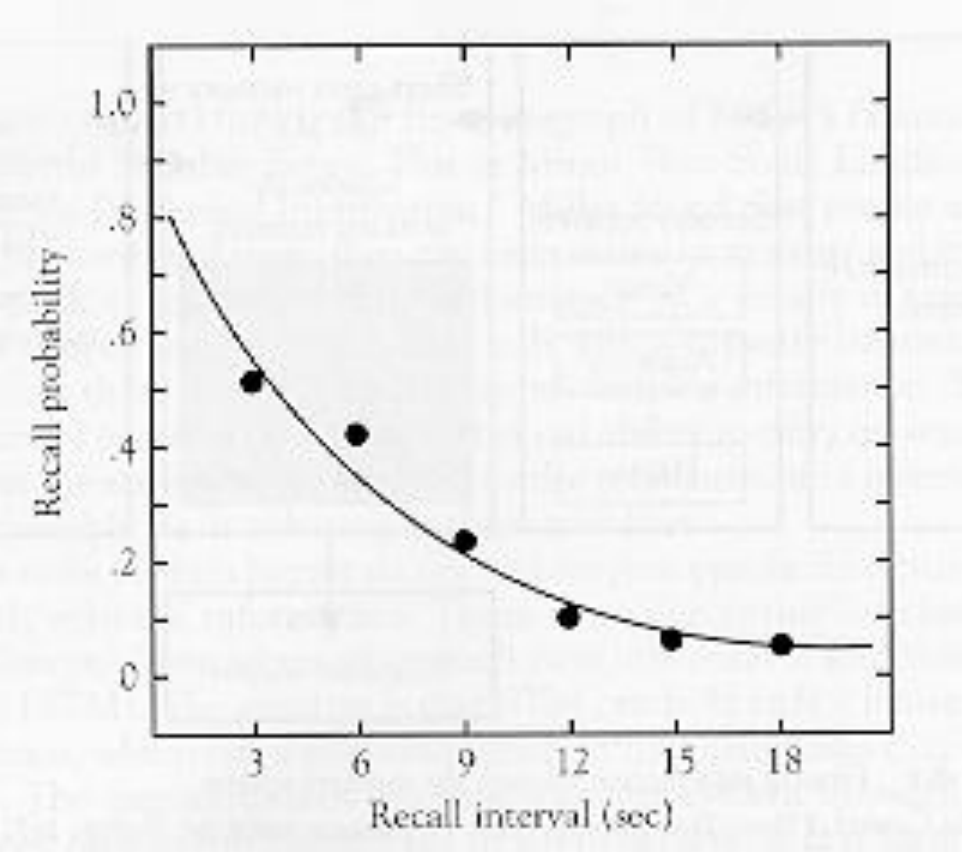
  …

- data shows strong performance decline with longer wait times

- The original interpretation is that performance decline was due to decay (the backwards counting task was included only to prevent the participant from engaging in active rehearsal of the items)

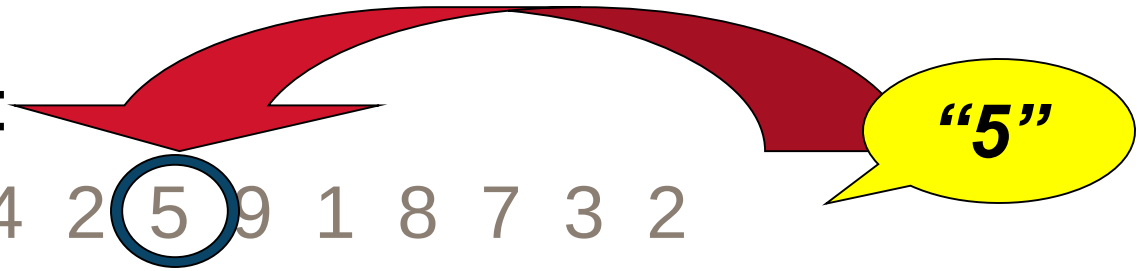
The Brown - Peterson Task (Loss from STM = Decay?)

- Peterson & Peterson interpreted this “BROWN - PETERSON TASK” result as supporting a "decay" interpretation.
- This has been challenged by an "interference" interpretation.
- The basic idea is that it is possible that the backwards counting task provided information that interfered with the memory for the original three letters.

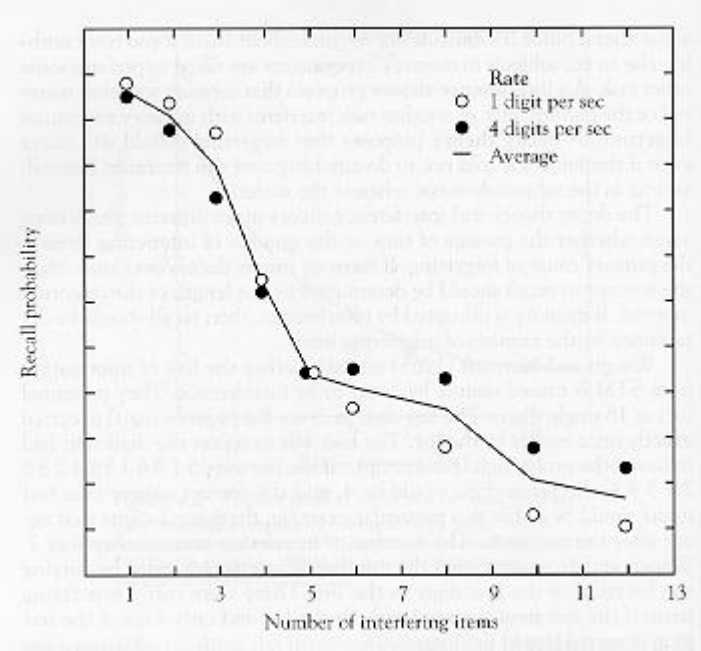


Waugh & Norman (Loss from STM = Interference?)

Probe-Digit task:



Varying the rate of presentation allowed Waugh and Norman to determine if it was the NUMBER of intervening items (Interference) or the TIME between the repeated items (Decay) that was critical to predict the loss of information from STM. Their results support an INTERFERENCE explanation.



Interference in Memory

Proactive Interference: old interfering with new information

- (e.g., which way do you look when crossing the street in London?)

Retroactive Interference: new information interfering with old information

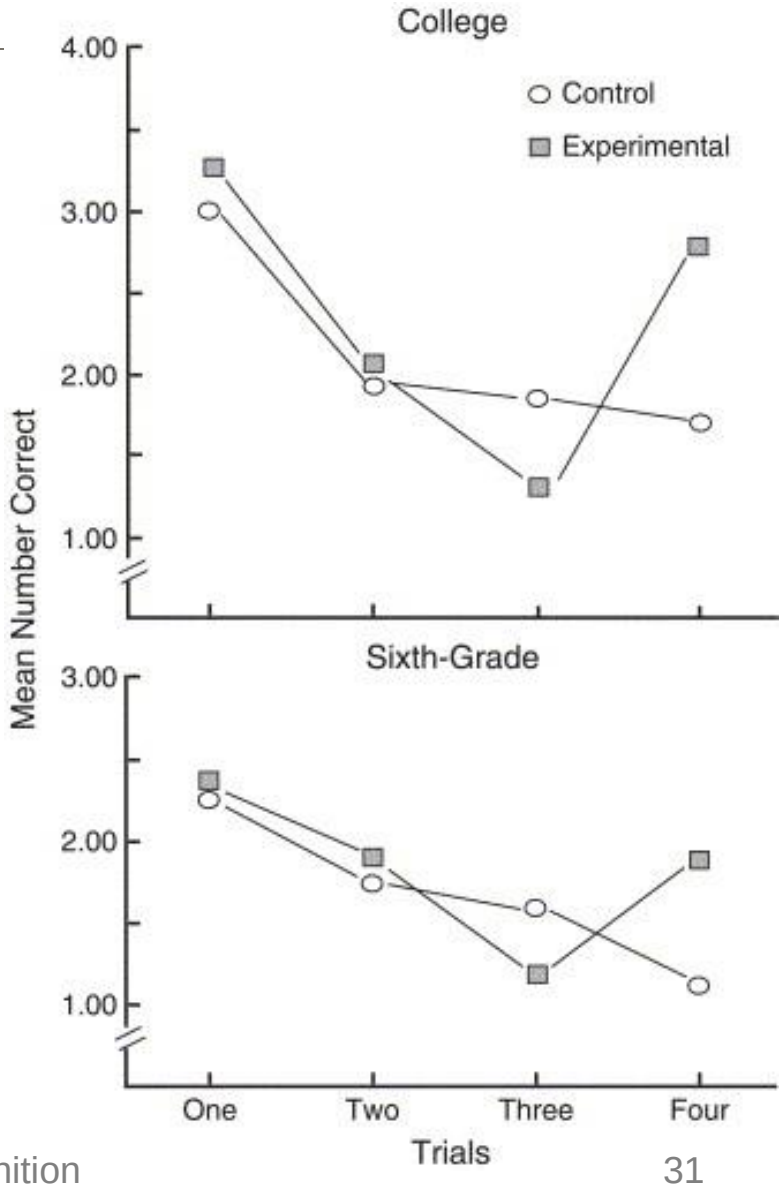
- (e.g., learning Italian after learning Spanish; now have trouble figuring out correct word in Spanish)

Release from PI (Proactive interference): when going through a series of lists a change in the topic of the lists will produce a rebound of improvement in memory recall for the new topic list because remembering and recalling the new list will not be interfered with by the previous items (old information) in the previous lists.

- (e.g., FLOWERS, FLOWERS, FLOWERS, PROFESSIONS)

Release from PI

when going through a series of lists a change in the topic of the lists will produce a rebound (improvement) in memory performance because remembering and recalling the items on the new list will not be interfered with by the items from the prior lists (the “old information”).



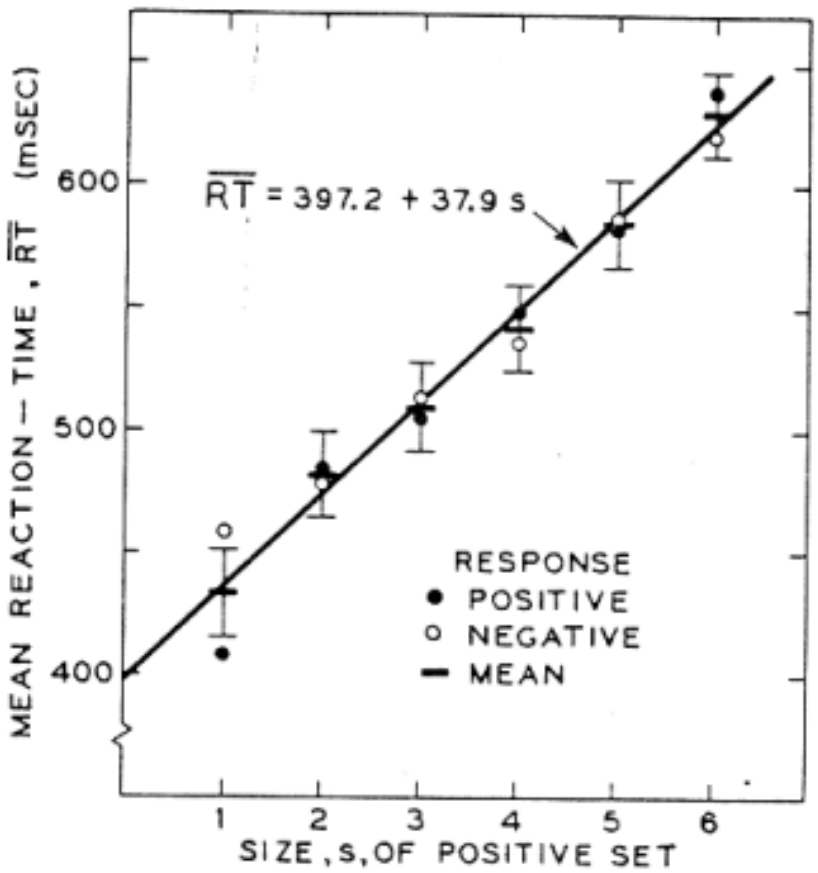
Release from PI

Wickens, Dalezman, &Eggemeier (1976) illustrates greater release from PI with word lists (triplets) from categories in the critical set that were semantically further away from the “fruits” category of the preceding ‘induction’ lists. (Kellogg p.113)

This suggests semantic codes in STM

Memory Search (Sternberg Search Task)

- Encode target set
- Encode probe
- Scan/compare (all sequentially)
- Binary yes/no (any fit?)
- Execute motor response



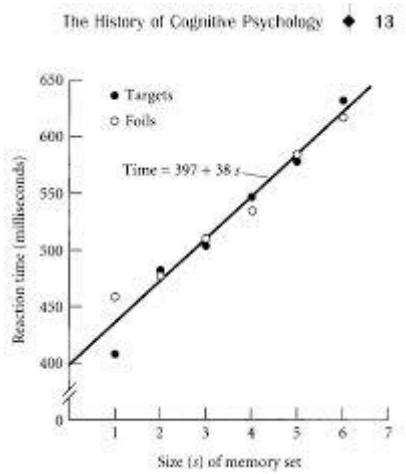
- e.g., { F O L P O Y Q } → L?

Data: → Serial-Exhaustive Search

Types of Search Functions

Serial Exhaustive

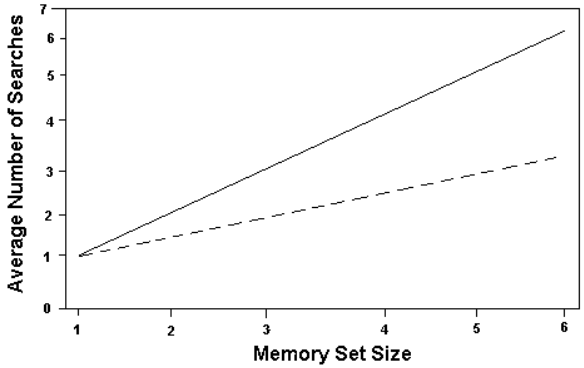
Memory Search



Serial Self-Terminating

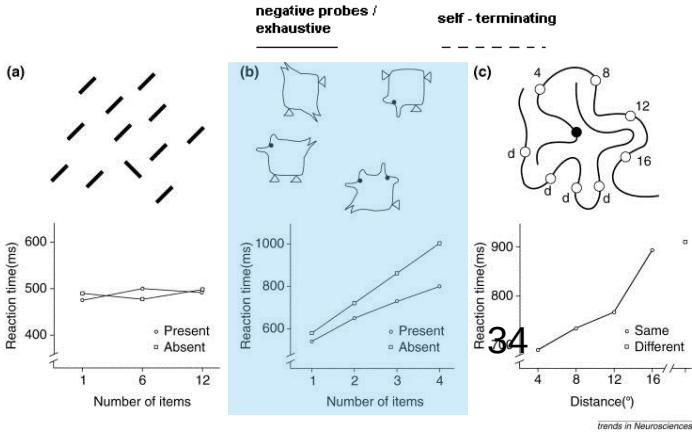
Visual Search (conjunction search)

- Search for "Chicken" among Distractors



Parallel

Visual Search (Feature search)



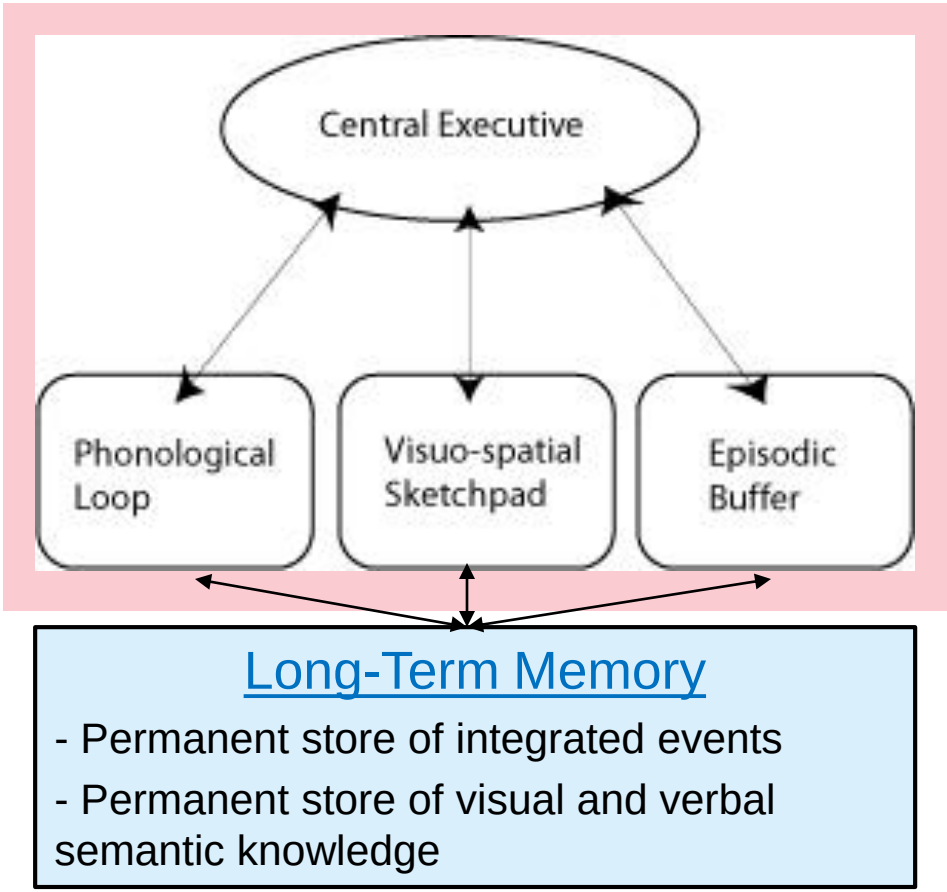
Integrating LTM and STM
(Baddeley's Multicomponent model of working memory)

Central Executive:
- Supervisory control
- Coordinates storage areas
- Focusses and switches attention
- Retrieves representations from LTM

Visuo-Spatial Sketchpad:
- Transient storage (visual/spatial) rep.
- Rehearsal/generation of images
- Action preparation

Phonological Loop:
- Transient storage (verbal) rep.
- Rehearsal for "inner speech"

Episodic Buffer:
- Transient storage of integrated events



DISTINGUISHING MEMORY SYSTEMS FROM EACH OTHER

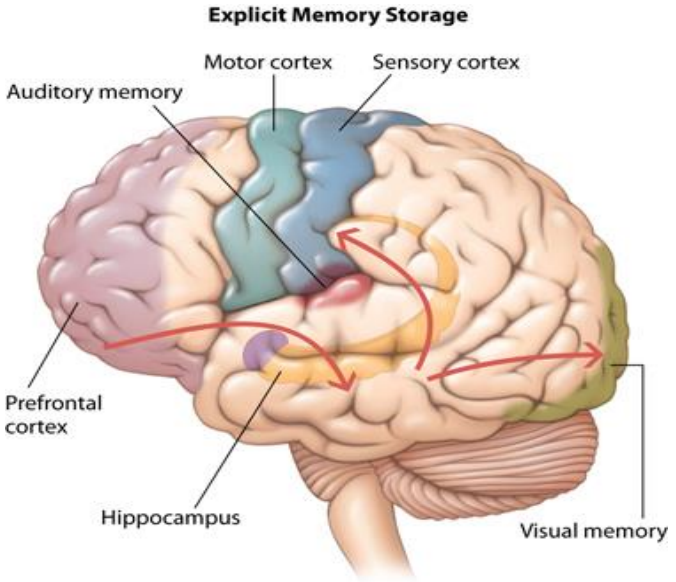
	Sensory	Short Term	Long Term
Duration	250 ms.	20 seconds	Years
Capacity	Large	3-5 “chunks” (Kellogg, p.108,111)	Very Large

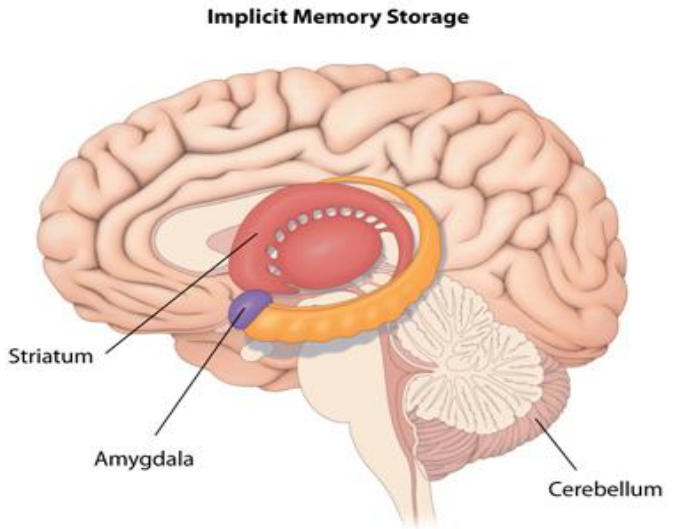
The Neurobiology of Memory

SENSORY CORTEX

Vision	→	Occipital lobes
Hearing	→	Temporal lobes
Touch	→	Parietal lobes

Different types of long-term memory are stored in different places in the brain





SUMMARY

The Atkinson & Shiffrin “Standard Model” distinguishes among Sensory, Short-Term, and Long-Term Memory.

The hippocampus plays a central role in indexing locations of the distributed memory representation and is critical for long-term storage of new episodic memories

Primacy effects (serial position curve) are due to LTM, recency effects due to STM.

Baddeley’s Working Memory Hypothesis has three sub-components under the control of the central executive: Phonological Loop, Visuo-Spatial Sketchpad, and the Episodic Buffer. The embedded-process model holds STM to be the activated portion of LTM. Both models make similar predications and are supported by activation of distinct neural regions during processing.

Memory System Terminology

- Iconic Memory
- Echoic Memory
- Interference
- Serial Position Effect
- Primacy Effect
- Recency Effect
- Anterograde Amnesia
- Standard Model of Memory
- Seven Sins of Memory
- Retrograde Amnesia
- Semantic Codes (in WM)
- Sternberg Search Task
- Consolidation
- Chunking
- Brown-Peterson Task
- Probe-Digit Task
- Chunking
- Decay
- Dual-Coding Theory
- Infantile Amnesia
- Phonemic Similarity Effect
- Proactive Interference
- Retroactive Interference
- Parallel Search
- Serial Search
  - Self-Terminating Search
  - Exhaustive Search
- Working Memory

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