CmpE 489: Cognitive Science

Memory

Adapted from Albert Ali Salah's slides

+ mostly from Introduction to Psychology, Memory Chapter

Semantic memory

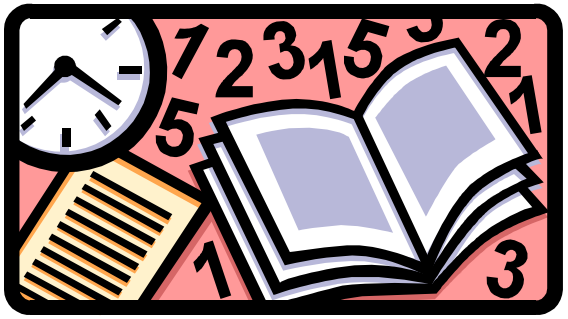
- Feature comparison model
  - Defining features vs. characteristic features
  - Typicality effect
- Prototype model
  - Priming effects
- The exemplar approach
- Network models
  - Spreading activation model
  - ACT model of declarative memory
  - Connectionist models (PDP)

Overview

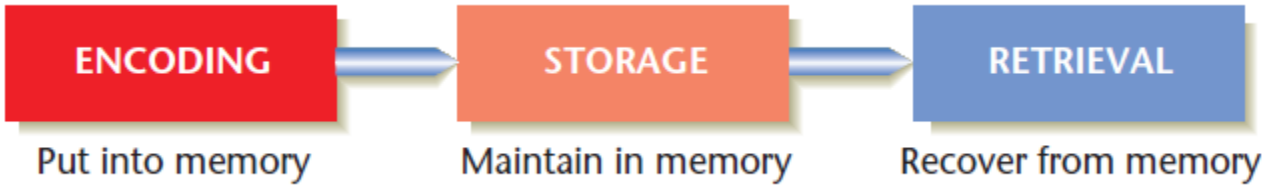
- Constructing memories
- Explicit vs. implicit memory
- Information processing (three-boxes) model of memory
- Sensory memory
- Short term memory
- Long term memory

Memory

- Process by which information is:
  - Acquired
    - Encoding
  - Stored in the brain
    - Storage
  - Later retrieved
    - Retrieval
  - Eventually (possibly) forgotten



Three stages



- Meet with somebody
- Encoding
  - Transform physical input (sound waves/pattern of light) into a code
- Storage
- Retrieval
  - Based on stored representation of face, remember you met her, recover the name

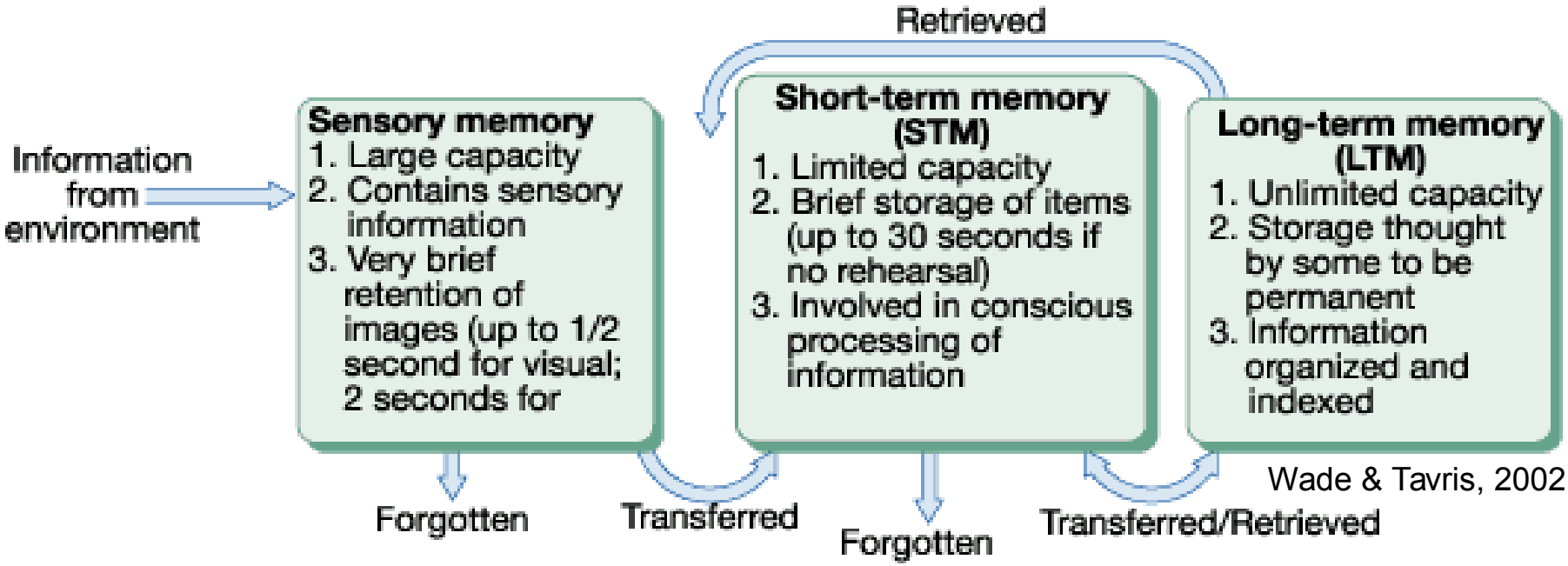
Brain and stages

- Participant A: study a set of verbal items – for example, pairs consisting of categories and uncommon instances (furniture–sideboard)
- Participants B: have to recognize or recall the items when cued with the category name
- PET
  - A: most of the activated brain regions are in the left hemisphere,
  - B: Most of the activated brain areas are in the right hemisphere
- QUIZ: Interpretation?

Information-Processing Model of Memory

- Computer as a model for our memory
- Three types of memory
  - Sensory memory
    - Large, transient (~3 sec), if attended ..
  - Short-term memory (STM)
    - Consciousness, accessible for tasks, decay (~20sec), decay prevent with rehearsal, elaboration
  - Long-term memory (LTM)
    - Size and range unlimited, acquired via retrieval, placed back to STM

Information-Processing Model of Memory - II



Wade & Tavris, 2002

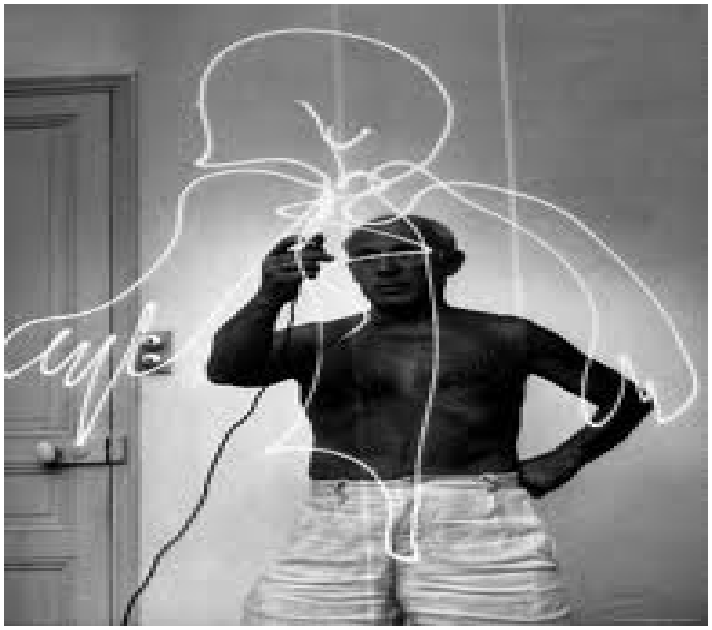
3 memory stores - Atkinson-Shiffrin theory

Explicit vs. implicit memory

Sensory memory

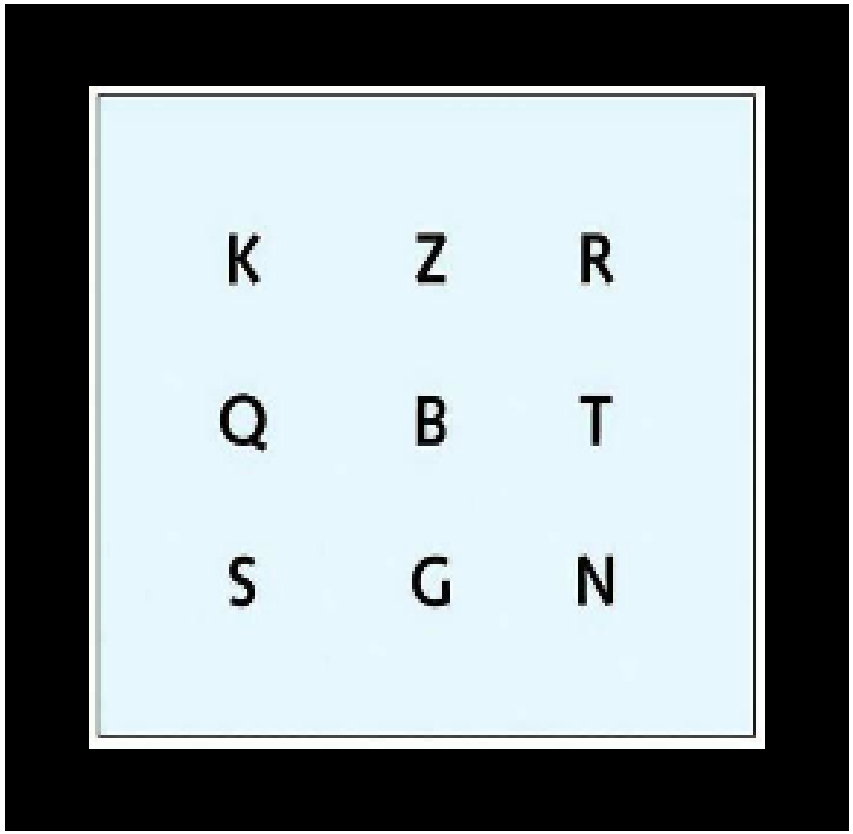
- Iconic memory

Sensory Memory



- Stores all the stimuli that register on the senses
- Lasts up to three seconds
- Two types
  - Iconic memory
    - Visual
    - Usually lasts about 0.3 seconds
    - Sperling's tests (1960s)
  - Echoic memory (we'll come back to this)

Sperling’s experiment I

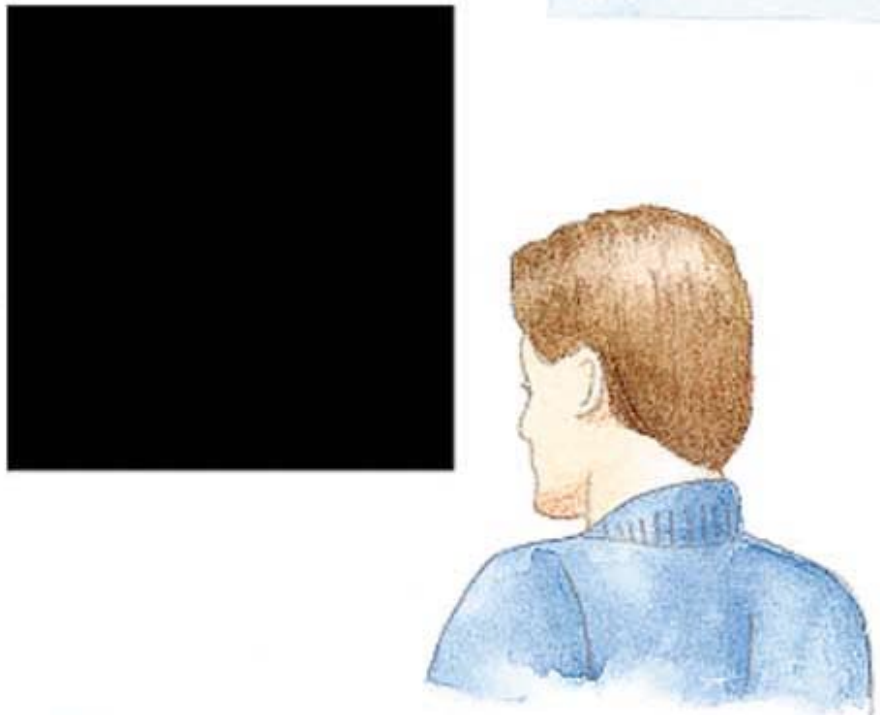


Sperling’s experiment

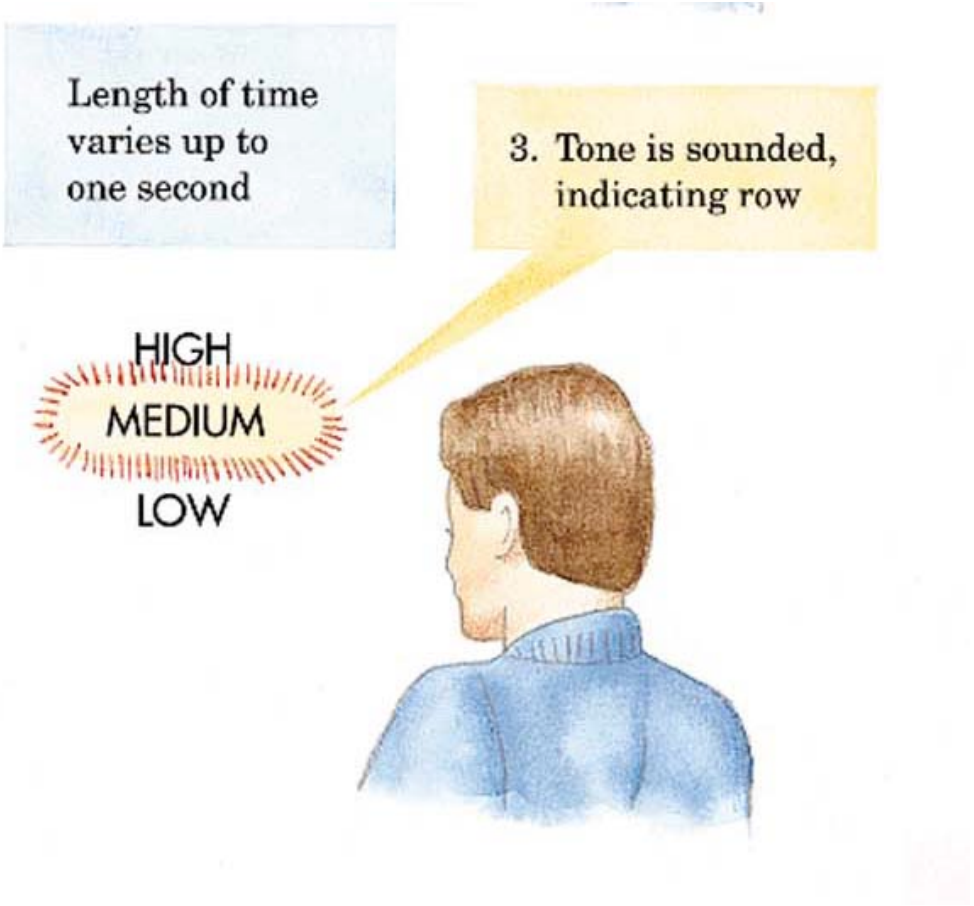
1. Letters are displayed on a screen for 1/20 of a second

Sperling's experiment

2. Screen is blank



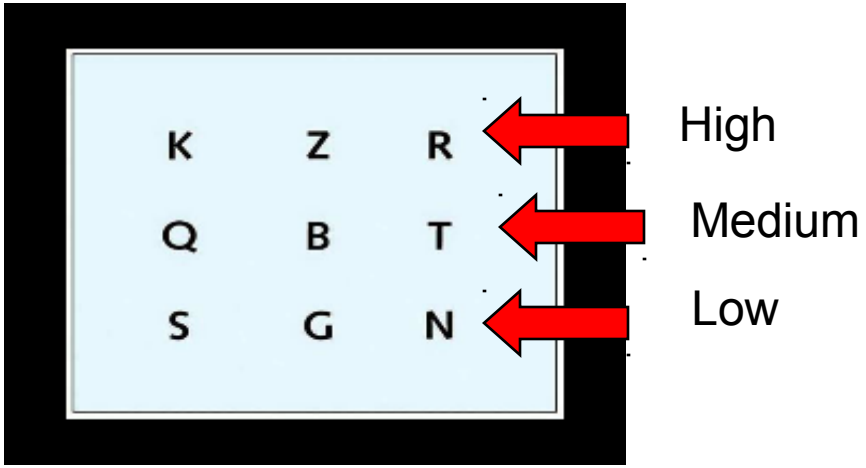
Sperling's experiment



Sperling's experiment

Sperling's experiment

- Sounded low, medium or high tone immediately after matrix disappeared
  - Tone signaled one row to report
  - Recall was almost perfect
- Memory for images fades after 1/3 seconds or so, making report of entire display hard to do
- Is it an afterimage?

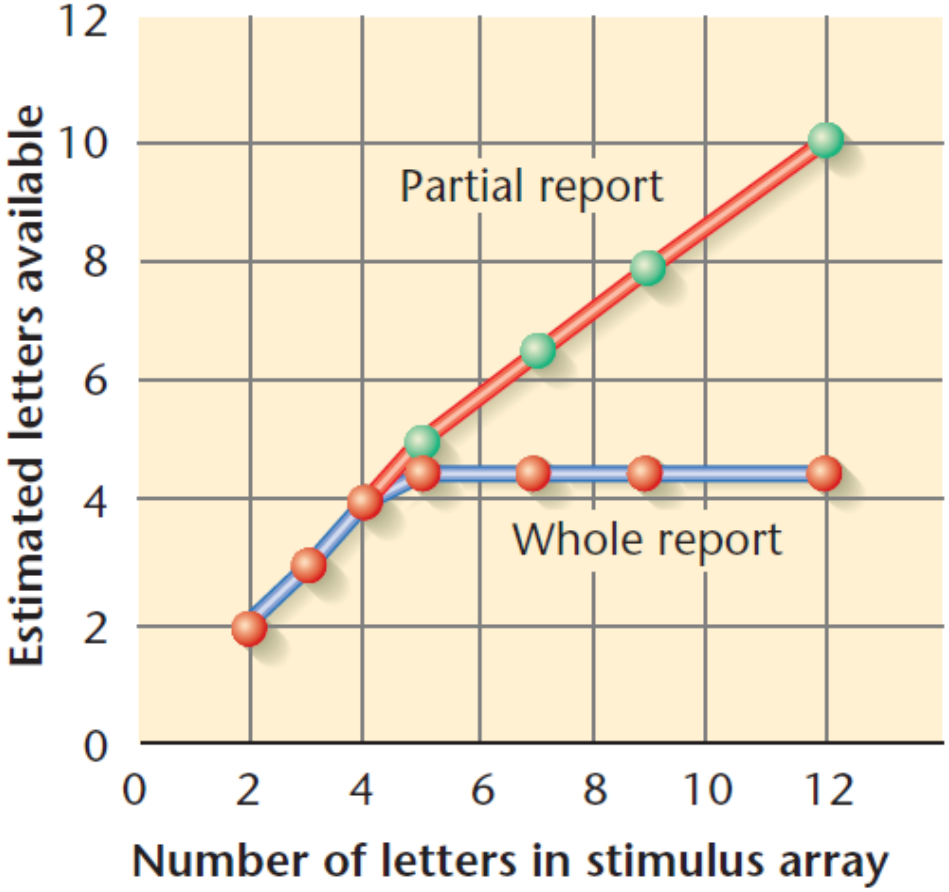


partial-report procedure

- about a twentieth of a second
- two report conditions.
  - whole-report condition, the observer simply reported as many letters as possible
  - new, partialreport condition the observer had to report only one of the rows of letters
- an auditory cue presented immediately after the array and told the observer which row was to be reported: A high tone indicated the top row,

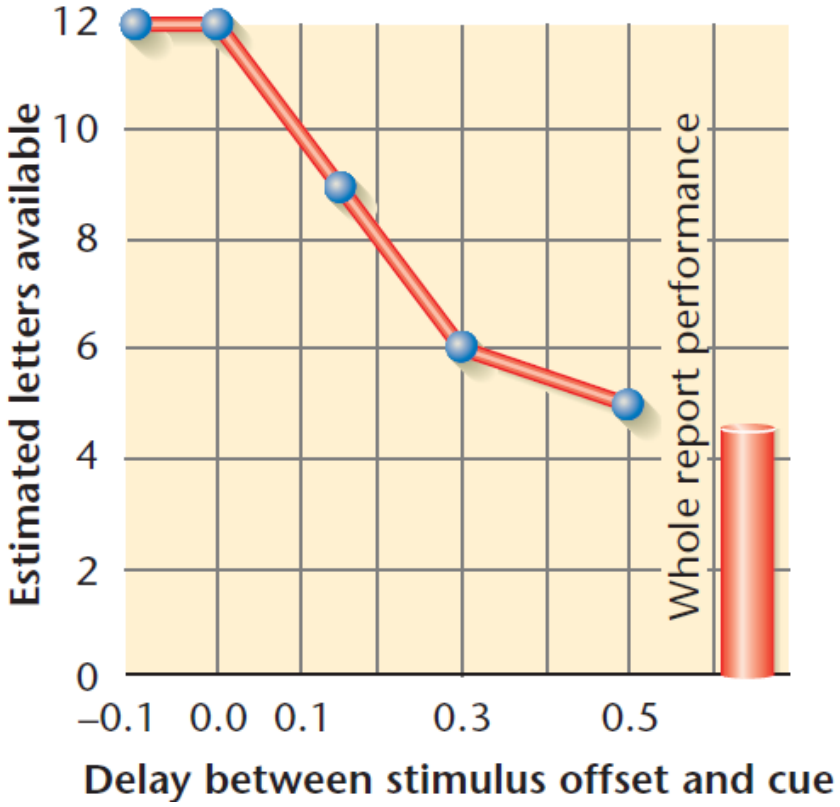
1st experiment

- Sperling estimated how many letters the observer had available by multiplying the average numbers of letters the observer was able to report from the indicated row by the number of rows.



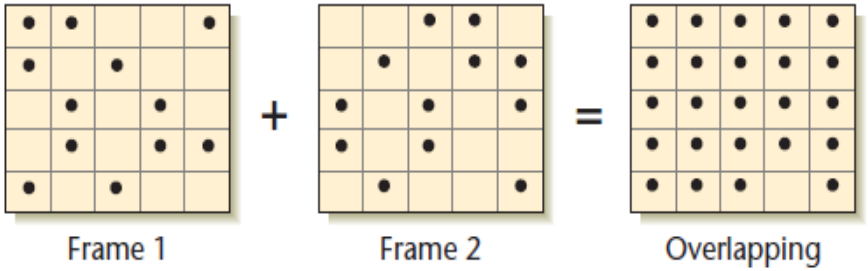
2nd experiment

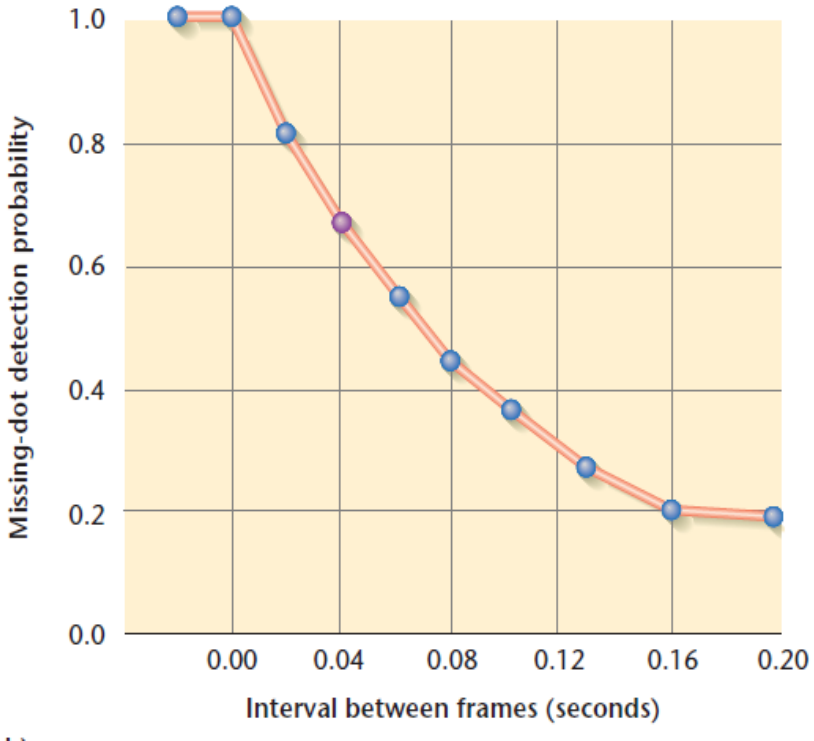
- Sperling kept the number of letters in the array constant – 12 in our example – but varied the delay between the offset of the letter array and the auditory row-indicating cue, using a partial-report procedure.



Di Lollo (Di Lollo 1980) temporal integration paradigm

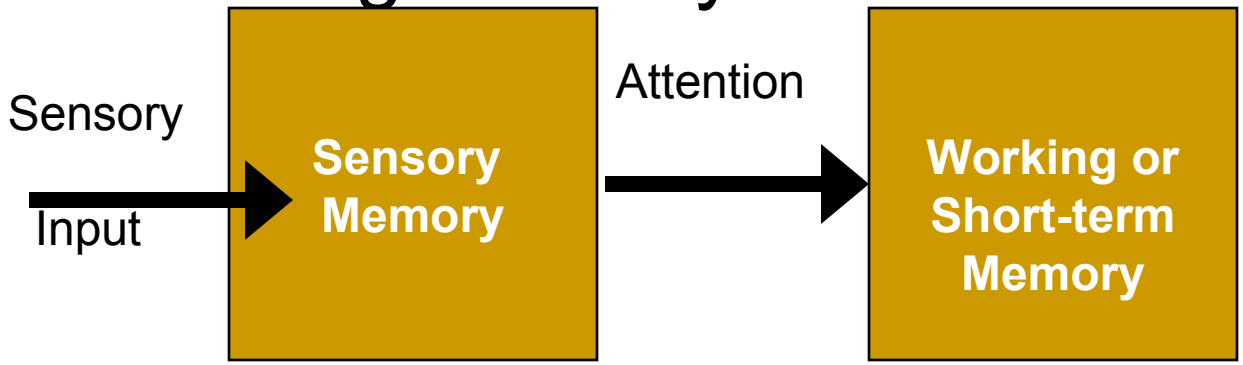
- report the location of the missing dot
- stimulus was presented as two ‘frames’ of 12 dots per frame
- performance declined precipitously as the inter-frame interval increased up to about 150 ms.
- Interpretation?





Short-term memory I

- Function
  - Conscious processing of information
  - Attention is the key
    - Limits what info comes under the spotlight of short-term memory at any given time
- AKA working memory

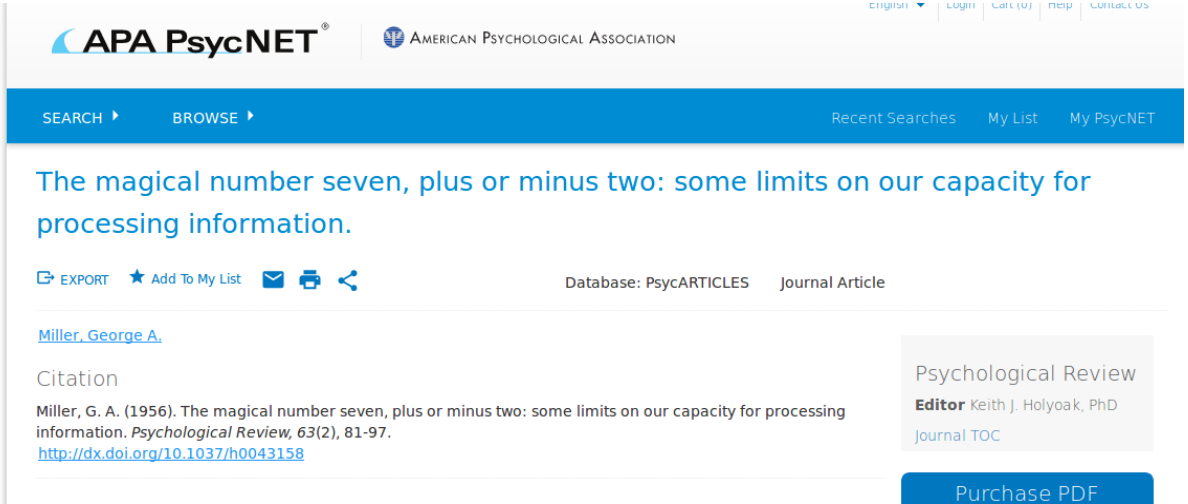


Phonological coding

- it is entered in a certain code or representation
- you look up a phone number and retain it until you have dialed it, in what form do you represent the digits?
  - a mental picture of the digits or is it phonological
- we favor a phonological code when we are trying to keep the information active through rehearsal – that is, by repeating an item over and over
- a list of six consonants (for example, RLBKSJ) – RLTKSJ
-

Short-term Memory II

- Limited capacity
  - Can hold 7 ± 2 items for about 20 seconds
  - Maintenance rehearsal
    - The use of repetition to keep info in short-term memory
- CHUNK
  - Meaningful unit of information
  - Without rehearsal, we remember 4 ± 2 chunks
  - With rehearsal, we remember 7 ± 2 chunks



Memorize the following numbers:

9 1 4 5 3 8 1 7 8 9 7 1 8 8 1 6 1 9 2 3 5

Write down the numbers in order!

Now try again:

9 1453 8 1789 7 1881 6 1923 5

Short-term Memory

Chunking

- SRUOYYLERECNIS
  - from 14 to 2 (the 2 words).
- use long-term memory to perform what is known as chunking
- capacity of working memory is best expressed as 7±2 chunks

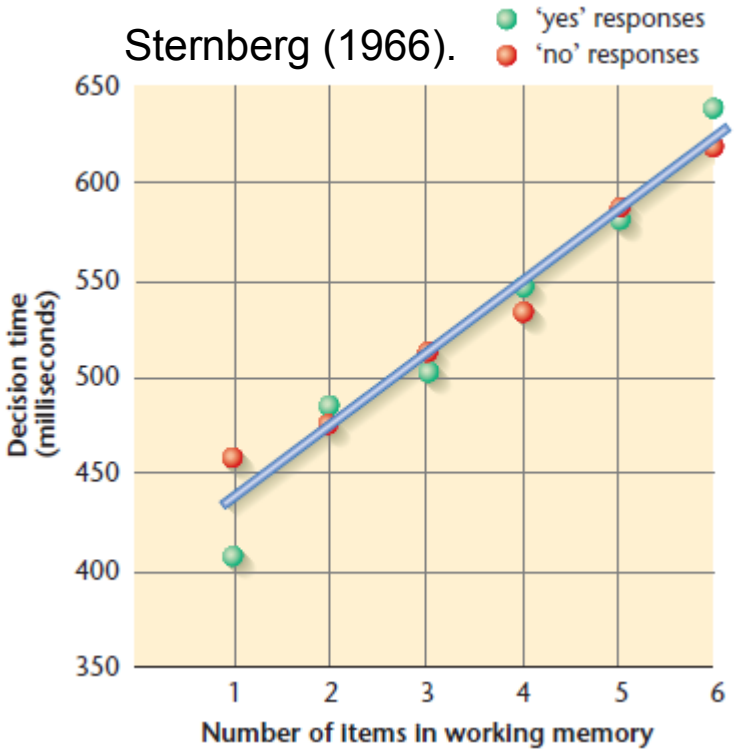
Forgetting

- a trace that fades within a matter of seconds
  - our working memory span holds fewer words when the words take longer to say
- the displacement of old items by new ones working
  - memory has a fixed capacity.
  - Perhaps only about seven items can be simultaneously maintained at a level of activation that permits all of them to be recalled.

Retrieval in working memory

- Active in consciousness.
- Information is right there?
- But more item more time.
- if the memory list is 3 6 1 and the probe is 6
- adds a fixed amount of time to the retrieval process
- Interpretation:
  - Retrieval requires a search of working memory.
  - More items, less activation for each.

Sternberg (1966).

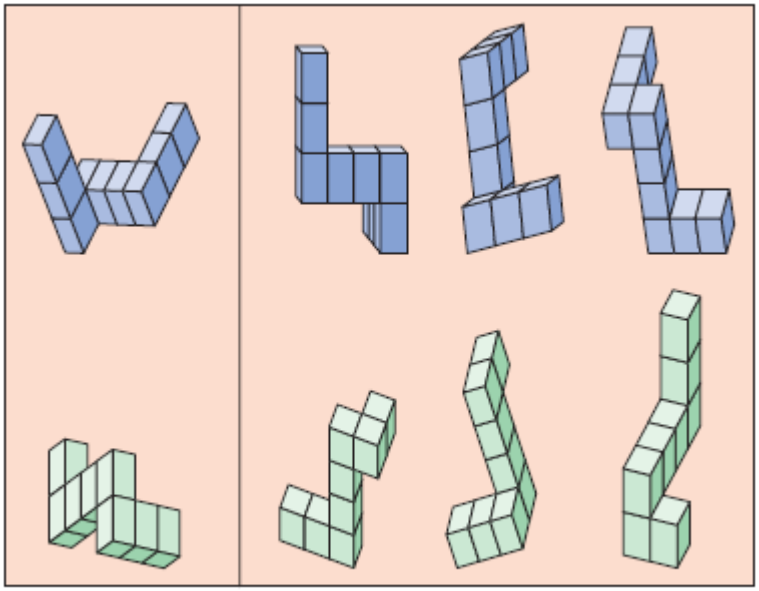


Visual coding

- Maintain verbal items in a visual form.
- When a person must store nonverbal items, the visual code becomes more important.
- The task of fitting several pieces of luggage into the back of one's car
- Some kind of visual image in working memory

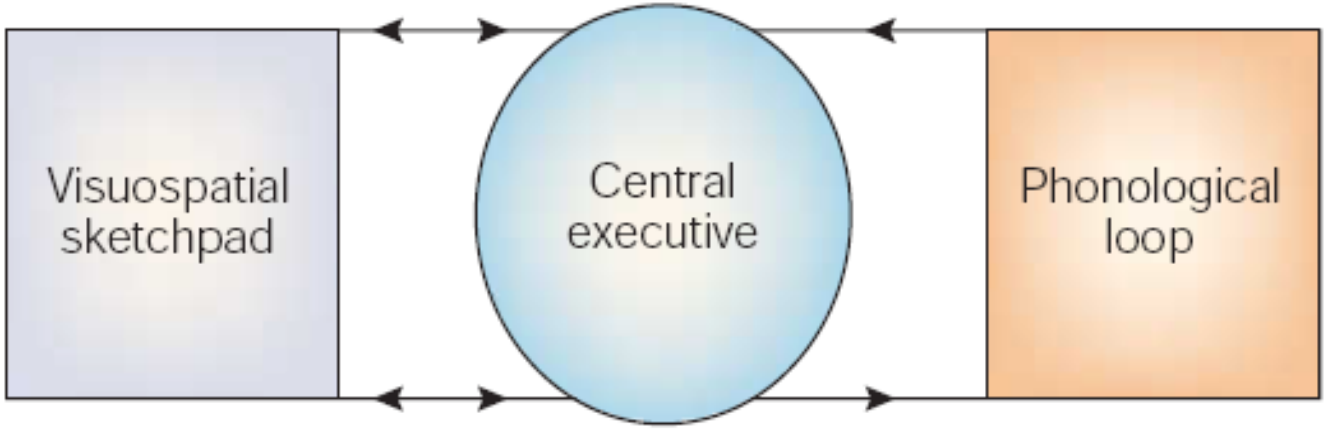
Current conceptions of working memory

- Several distinct workspaces or buffers
- One system for storing and operating upon information in an acoustic code.
- A second system (visual-spatial sketchpad) holds and operates upon visual or spatial information
- are mediated by different brain structure



Mental rotation stimuli

The Baddeley & Hitch WM model (1974): 3 components of WM



Slave system for Visuo-spatial information (colour, location, shape)

Central system allocating attentional resources to the 2 slave systems - modality-independent

Slave system for acoustic-phonological informations. Mechanisms: rehearsal loop and recoding

Baddeley (2003:830)

Third version: Dividing the Central Executive

The simplifying assumption of CE as a unitary attentional system has been given up in favour of a multiple CE:

3 Tasks:

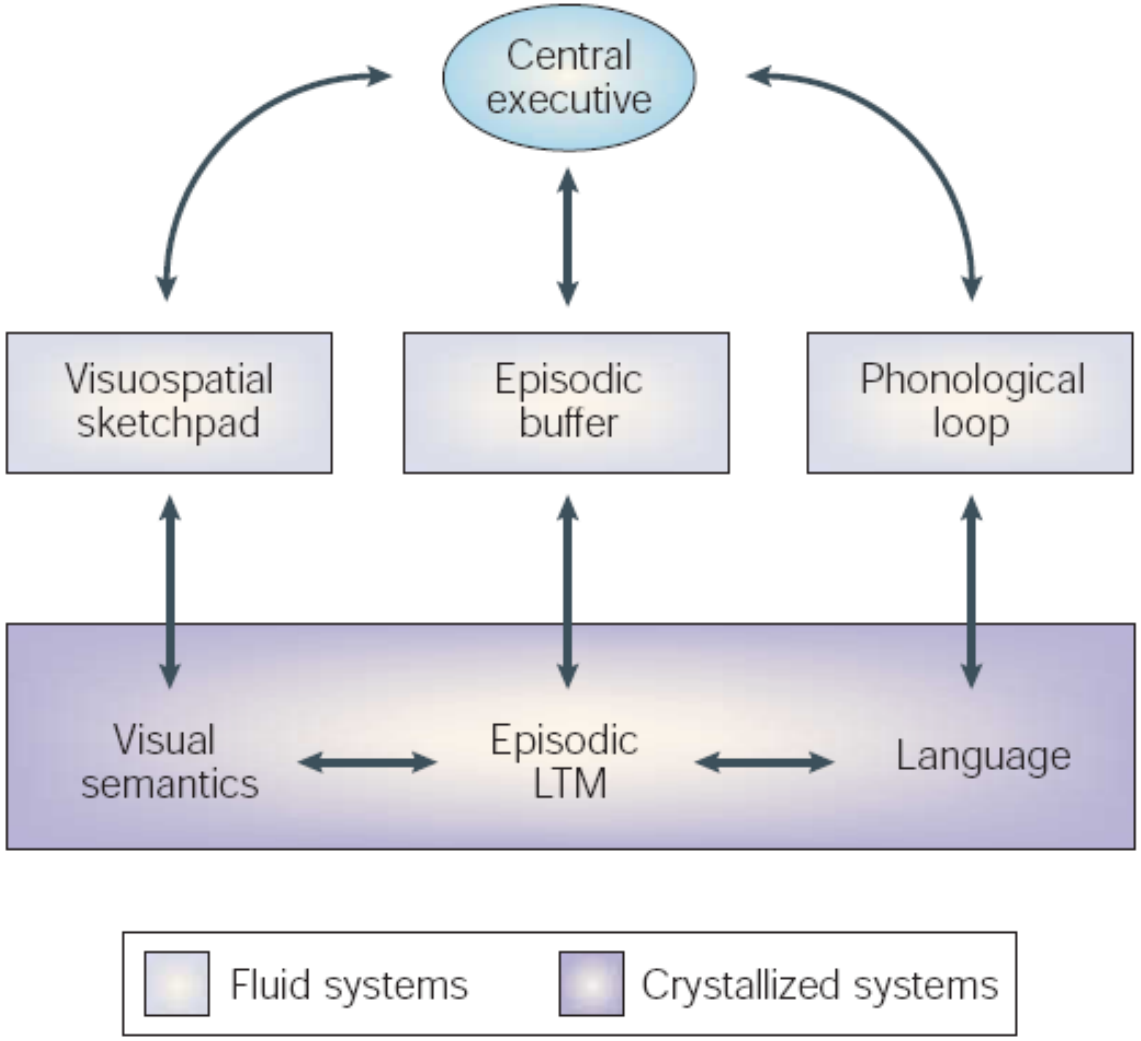
- Attentional control, i.e., focus, divide and switch attention
- Connect WM with LTM, e.g., for chunking (allowing information in LTM to supplement immediate serial recall)
- Allowing the slave systems to interact, in a separate WM component, distinguishable from LTM --> The Episodic buffer

Baddeley 2000, 2003

Fourth component: The episodic buffer

'Limited capacity store that binds together information to form integrated episodes. It is assumed to be attentionally controlled by the executive and to be accessible to conscious awareness. Its multi-dimensional coding allows different systems to be integrated, and conscious awareness provides a convenient binding and retrieval process.' (Baddeley, 2003)

Fourth component: The episodic buffer



Baddeley, A. (2003)

Episodic buffer

- How do the phonological loop and the visual-spatial sketchpad interact with one another?
- Master slave
- additional component of working memory, called the episodic buffer
- important function of this subsystem is to bind or associate different aspects of a memory
- phonological loop may store a person's name
- visual-spatial sketchpad her face–
- but the episodic buffer would associate the two so that the name and face 'go together'

Biological implementation of the Episodic Buffer

- 'Binding' of information through synchronous firing of nerve cells in nerve cell assemblies
- No concrete anatomical location but involvement of the Prefrontal Cortex PFC (--> Central Executive)

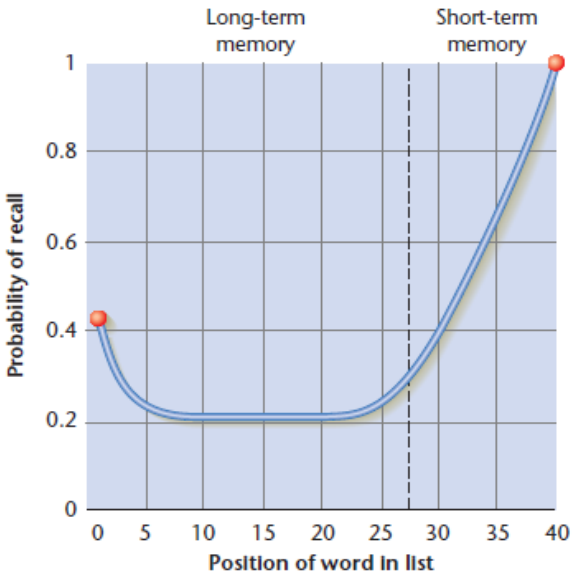
Right frontal lobes involved in combining two separate tasks, verbal and visual (Prabhakaran et al. 2000)

Retrieval and thought

- an important role in thought.
  - Store parts of the problem
  - Store information from LTM
- multiply 35 by 8 in your head
  - Use facts such as 8x5=40 and 8x3=24
  - try doing the mental multiplication just described while remembering the phone number 7
- a kind of blackboard
- for language processes

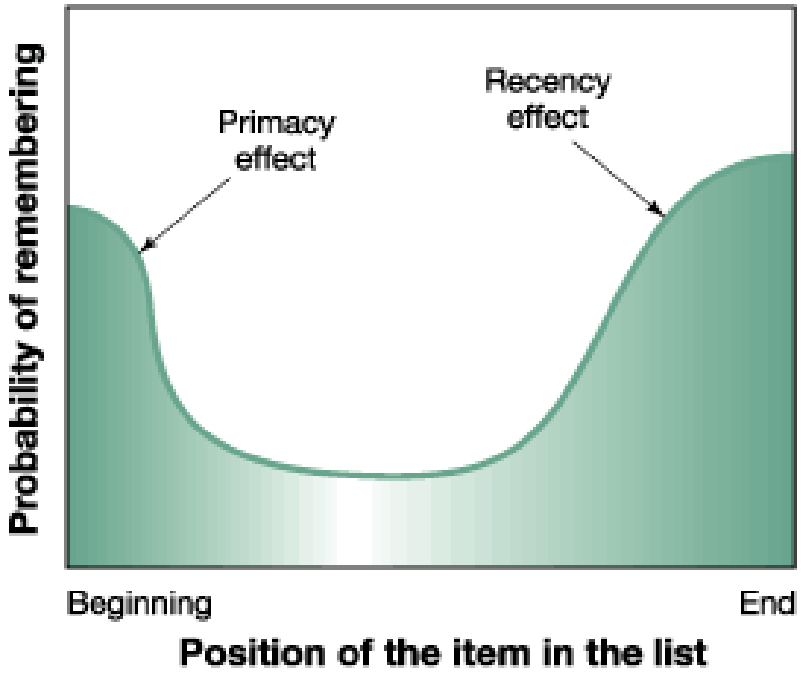
Transfer from working memory to long-term memory

- serves two important functions:
  - It stores material that is needed for short periods,
  - it serves as a workspace for mental computations.
- serving as a way station to long-term memory
- Rehearsal:
  - Maintenance rehearsal
  - Elaborative rehearsal
- Free-recall experiments



Serial-Position Effect

- The tendency for recall of first and last items on a list to surpass recall of items in the middle of the list.

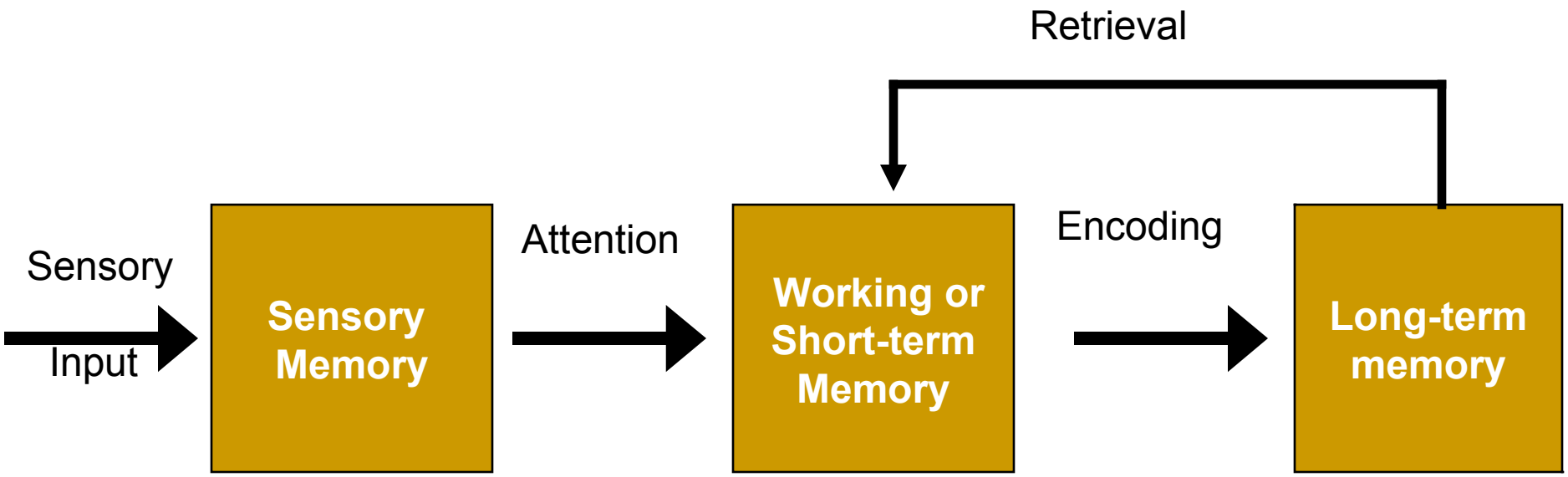


Working memory - summary

- hold roughly 7 plus/minus2 chunks of information in either
  - a phonological
  - or a visual format.
- Information is lost from working memory through either decay or displacement,
- is retrieved from this system by a process that is sensitive to the total number of items being kept active at any given time.
- is used to store and process information that is needed during problem solving,
- and therefore is critical for thought.

Long-term Memory

- Once information passes from sensory to short-term memory, it can be encoded into long-term memory



STM/LTM - hippocampus

- The hippocampus, is critical for long-term memory but not for working memory
- Monkey, square – delay – triangle.
  - Long delay (15 sec)
    - Hippocampus damaged: perform poorly
    - Frontal cortex damaged: normal
  - Short delay (few sec)
    - Frontal cortex damaged: perform poorly
    - Hippocampal damage: normally.
  - Interpretation?
- Human patients
  - medial-temporal lobe amnesia,
  - no damage in medial temporal lobe.

Long-term memory

- From several minutes to several decades
- Distinction between retrieval and storage difficult:
  - important interactions between encoding and retrieval occur in long-term memory.
  - whether forgetting from long-term memory is due to
    - a loss from storage or
    - to a failure in retrieval

Long-term Memory

- **Procedural memories**: Memories for performance of actions or skills.
  - "Knowing how"
- **Declarative memories**: Memories of facts, rules, concepts, and events; includes semantic and episodic memory.
  - "Knowing that"
- **Semantic memories**: General knowledge, including facts, rules, concepts, and propositions.
- **Episodic memories**: Personally experienced events and the contexts in which they occurred.

Long-term memory

- Procedural (Implicit)
  - Memories of behaviors, skills, etc.
    - Demonstrated through behavior
- Declarative (Explicit)
  - Memories of facts
    - Episodic – personal experiences tied to places & time
    - Semantic – general knowledge
      - Semantic network

Long term memory

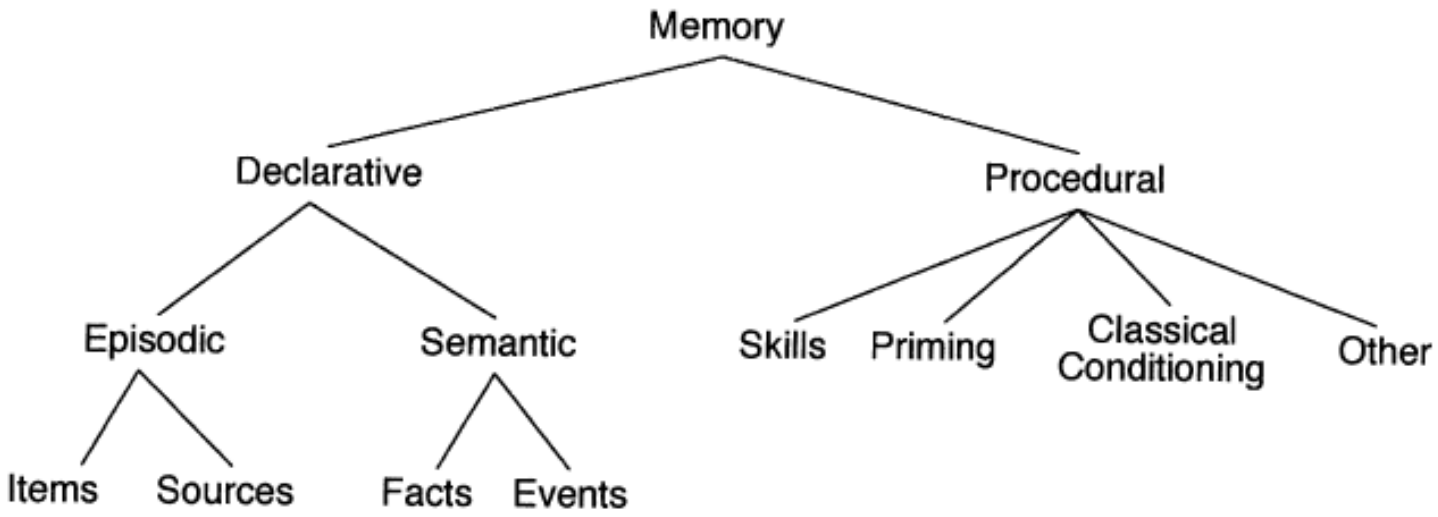


Figure 1 A taxonomy of various forms of long-term memory.

LTM - Encoding

- For verbal material, based on the meanings of the items.
  - “The author sent the committee a long letter”
  - Two minutes later: “A long letter was sent to the committee by the author”
- When people report on complex social or political situations, they may misremember many of the specifics
- Word-by-word memorizations, such as ?
- Phonological code memorization, such as ?
- What else?
- a preferred code for verbal material (namely, meaning), but other codes can be used as well.

LTM - Retrieval

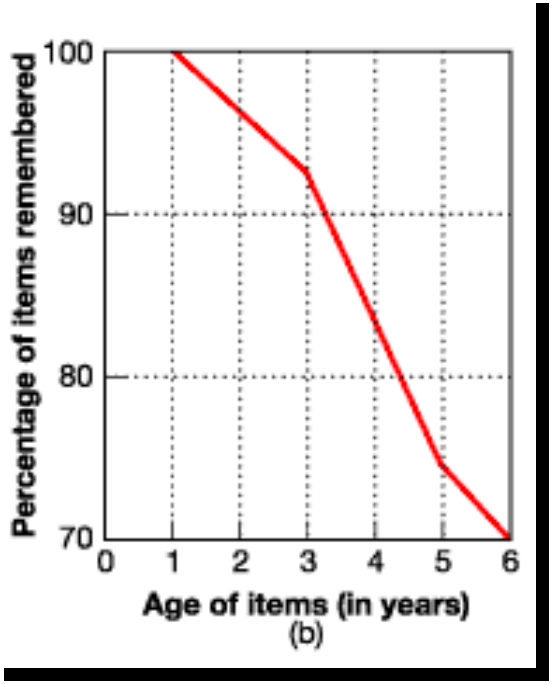
- Forget due to loss of access or loss of the information itself?
- Examples?
  - Forgotten words, tormented until a search of memory
  - a person undergoing psychotherapy retrieves a memory

List to be memorized		
dog	cotton	oil
cat	wool	gas
horse	silk	coal
cow	rayon	wood
apple	blue	doctor
orange	red	lawyer
pear	green	teacher
banana	yellow	dentist
chair	knife	football
table	spoon	baseball
bed	fork	basketball
sofa	pan	tennis
knife	hammer	shirt
gun	saw	socks
rifle	nails	pants
bomb	screwdriver	shoes

Retrieval cues		
animals	cloth	fuels
fruit	color	professions
furniture	utensils	sports
weapons	tools	clothing

Remembering Over Years

- Marigold Linton tested her own memory for personal events over a period of several years.
- Retention fell at a gradual but steady rate.

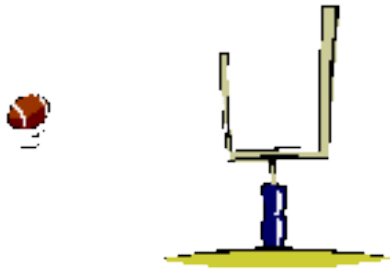


Decay

- **Decay Theory**: The theory that information in memory eventually disappears if it is not accessed; it applies more to short-term than to long-term memory.
- No longer a valid theory of forgetting
- Jenkins & Dallenbach (1924):
- “The results of our Study as a whole indicate that forgetting is not so much a matter of the decay of old impressions and associations as it is a matter of the interference, inhibition, or obliteration of the old by the new.”

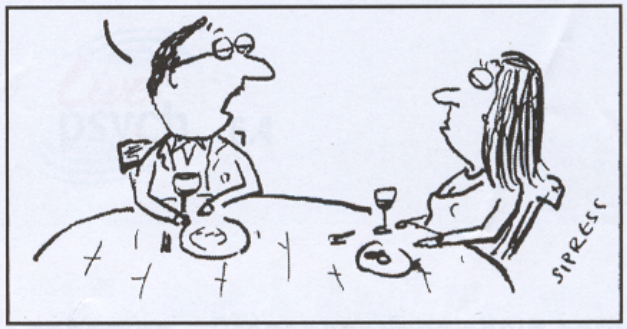
Interference theory

- Forgetting is a result of some memories interfering with others
  - Proactive interference
    - Old memories interfere with ability to remember new memories
  - Retroactive interference
    - New memories interfere with ability to remember old memories
  - Interference is stronger when material is similar



Forgetting - Repression

- Repression
  - There are times when we are unable to remember painful past events
  - While there is no laboratory evidence for this, case studies suggest that memories can be repressed for a number of years and recovered in therapy



I recently recovered a crucial repressed memory. But then I forgot it.

Forgetting: loss of information

- Electroconvulsive therapy
- Retrograde amnesia (for events occurring in the weeks or months before treatment)
  - recovery of loss for old memories was "virtually complete" by post-treatment
- Loses some memory for events that occurred in the months just prior to the shock
- These memory losses are unlikely to be due to retrieval failures. Why?

- **neuroanatomical bases of consolidation**
  - the hippocampus and the cortex surrounding the hippocampus
- The hippocampus's role in consolidation: cross-referencing system

Forgetting: loss of information - M

- (Squire, 1992; Zola- Morgan& Squire, 1990)
  - 100 pairs of objects, one with food, the other without
  - 20 learned 16 weeks before
  - Additional 20 learned 12, 8, 4, 2 weeks before
  - hippocampal surgery
  - 2 weeks later:
    - remembered the discriminations learned 2 or 4 weeks before surgery less well than the control monkeys did.
  - These results suggest that memories need to be processed by the hippocampus **for a period of a few weeks**, for it is only during this period that memory is impaired by removal of the hippocampus.

Encoding vs. retrieval

- Retrieval is affected when, during encoding
  - More elaboration
  - Organizing information
    - Into categories
  - During retrieval, context is similar
    - Easier if you are in the same context.

LTM – summary

- hold information for days, years, or decades,
- typically in a code based on meaning, although other codes are possible.
- Retrieval of information from this system is sensitive to interference;
  - many apparent ‘storage losses’ are really retrieval failures.
- Storage in this system involves consolidation,
  - a process that is mediated by the hippocampal system.
- Many aspects of long-term memory can be influenced by emotion;
  - such influences may reflect selective rehearsal,
  - retrieval interference,
  - the effects of context,
  - two special mechanisms: flashbulb memories and repression.

Implicit memory

- One that is often manifested in skills and shows up as an improvement in the performance of some perceptual, motor, or cognitive task without conscious recollection of the experiences that led to the improvement

Memory in amnesia (partial loss of memory)

- Unable to either remember old facts about their lives or learn new ones
  - **anterograde amnesia:** inability to remember day-to-day events and, hence, to acquire new factual information
  - **retrograde amnesia:** A secondary symptom of amnesia is inability to remember events that occurred prior to the injury or disease.
- No difficulty remembering and learning perceptual and motor skills.
- Biking, shoelace tying, mirror-reversed reading

Procedure for an experiment to study implicit memory in amnesia (Reprinted from Neuropsychologia, Vol. 16. pp. 169–172 by W. K. Warrington and L. Weiskrantz, 'Further Analysis of the Proper Learning Effect in Amnesiac Parents'. Copyright © 1978, with permission from Elsevier Science, Ltd.)

Stage 1	*Example*
Present list of words for study	MOTEL
Stage 2	
Present stems of list words and nonlist words for completion. Number of list words completed minus number of nonlist words completed = Priming	MOT BLA
Stage 3	
Present original list of words plus new words for recognition	MOTEL STAND

Creating memories

- Memory is selective.
- Recovering a memory is not playing a videotape
  - Memory involves inferences that fill in gaps in recall.
  - We are often unaware we have made such inferences.
- **Source Amnesia**: The inability to distinguish what you originally experienced from what you heard or were told later about an event.