Memory - I

IBC

Agenda

- Introductory lecture, broad overview
- Modal model
- Serial position curves and what we can infer about short term memory, long-term memory, etc

Clive Wearing

- The man with the 7 second memory
- http://www.youtube.com/watch?v=Vwigmktix2Y

What is memory?

- *THE ABILITY TO STORE AND RETRIEVE INFORMATION OVER TIME*

Memory Test

- Bed
- Sheets
- Xylophone
- Pillow
- Dream
- Rest
- Tired
- Snore
- Yawn
- Darkness
- Blanket
- Couch

REST

Memory Test

Sheets?

Sleep?

Dream?

Mattress?

Snore?

<u>Memory Illusion</u>:

False but subjectively compelling memory

We view memory like this:

It’s more like this

Reconstructive View of Memory

- Memories are not **reproduced** like a tape playing
- Memories are actively constructed and **reconstructed**

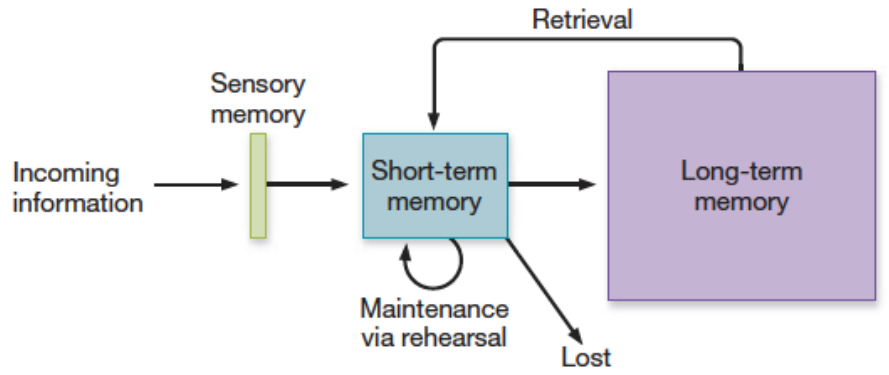
Memory

- **Memory**: the ability to store and retrieve information over time
- There are three key components of memory:
  - **Acquisition/Encoding**: the process by which we transform what we perceive, think, or feel into a memory.
  - **Storage**: the process of maintaining information in memory over time
  - **Retrieval**: the process of bringing to mind information that has been previously encoded and stored

How is information acquired?

- Atkinson and Shiffrin (1968): The modal model

FIGURE 6.1 AN INFORMATION-PROCESSING VIEW OF MEMORY



Diagrams like this one depict the flow of information hypothesized by the modal model. The model captures many important truths but must be updated in important ways. Current theorizing, for example, emphasizes that short-term memory (now called "working memory") is not a place serving as a "loading dock" outside of long-term memory. Instead, working memory is best understood as an activity, in ways described in the chapter.

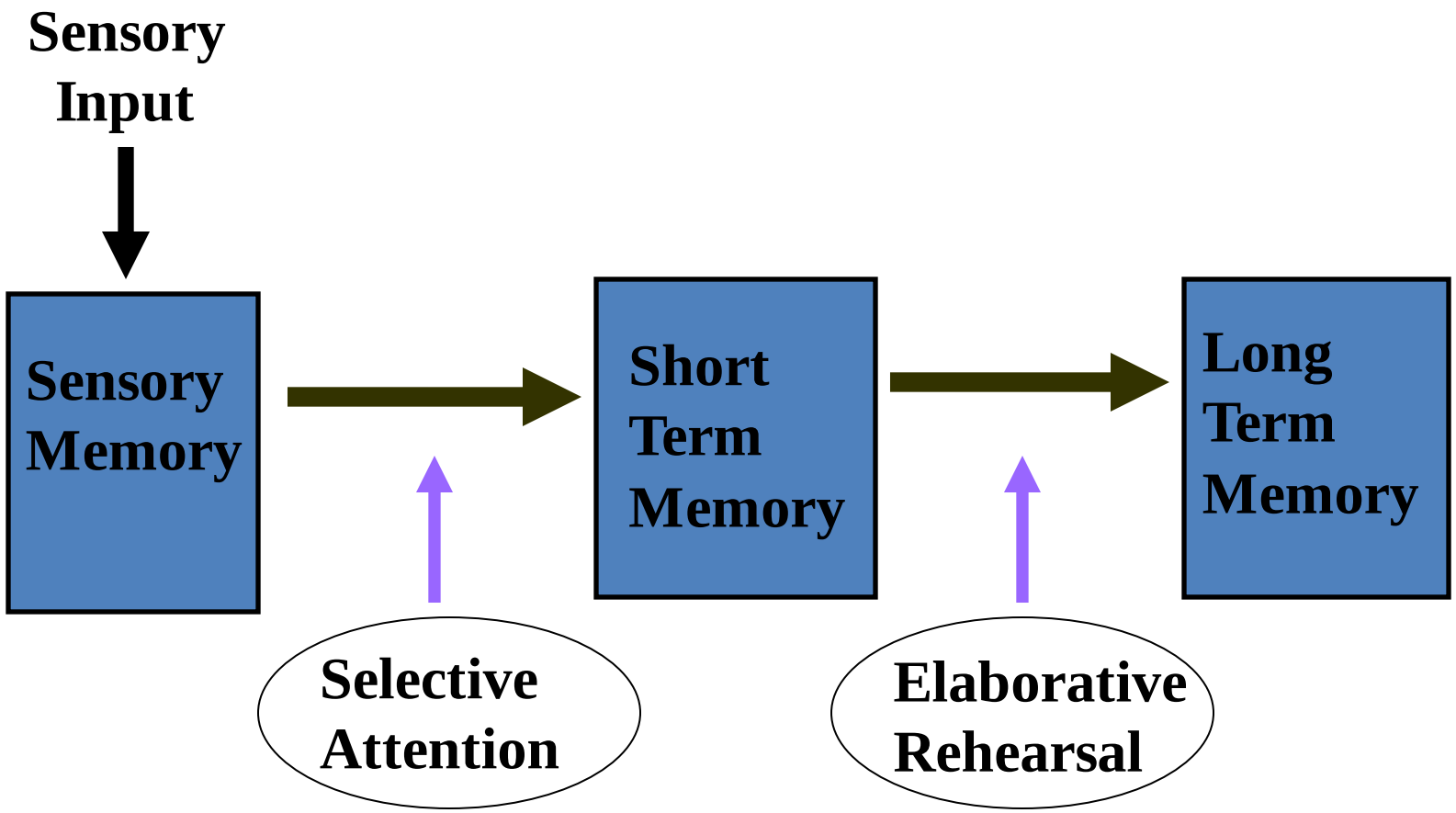
Storage

- There are three major kinds of memory storage:
  - **Sensory memory**: storage that holds sensory information for a few seconds or less
    - **Iconic memory**: a fast-decaying store of visual information
    - **Echoic memory**: a fast-decaying store of auditory information
  - Short-term memory (STM)
  - Long-term memory (LTM)

Three System Memory

	Sensory Memory	Short-term Memory	Long-term Memory
Function			
Span			
Duration			

Three Systems of Memory



Three Systems of Memory

- Each stage is different in terms of
  - **Span**: How much information
  - **Duration**: How long
  - **Function**: What is done with the stored info

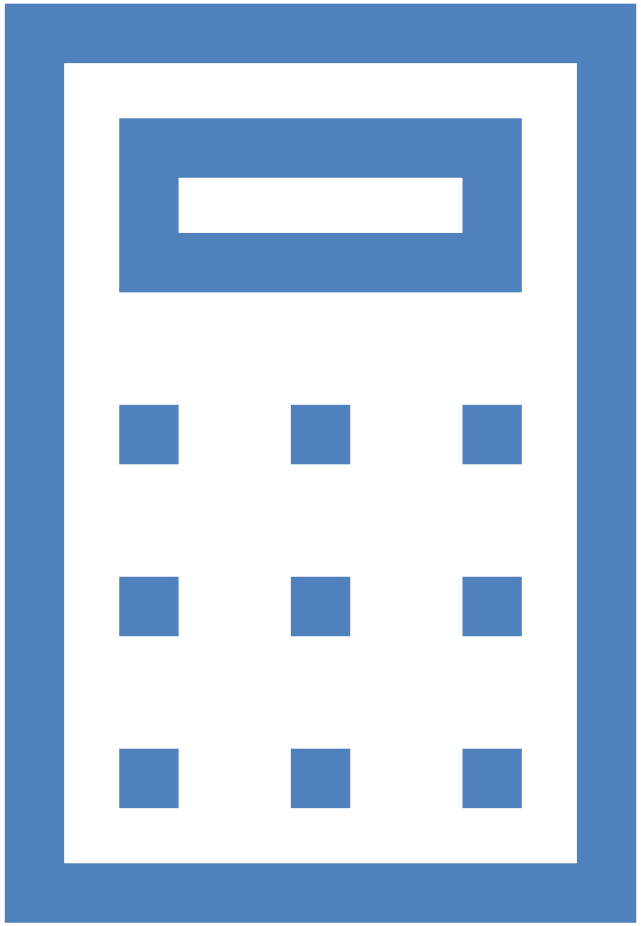
Sensory Memory

- Sensory registers: temporary storage of sensory information
- Registers a great deal of information from the environment
- Separate sensory memory exists for each sense
- Quickly fades: less than 1 sec (visual) or a few sec (auditory)

Sensory Memory

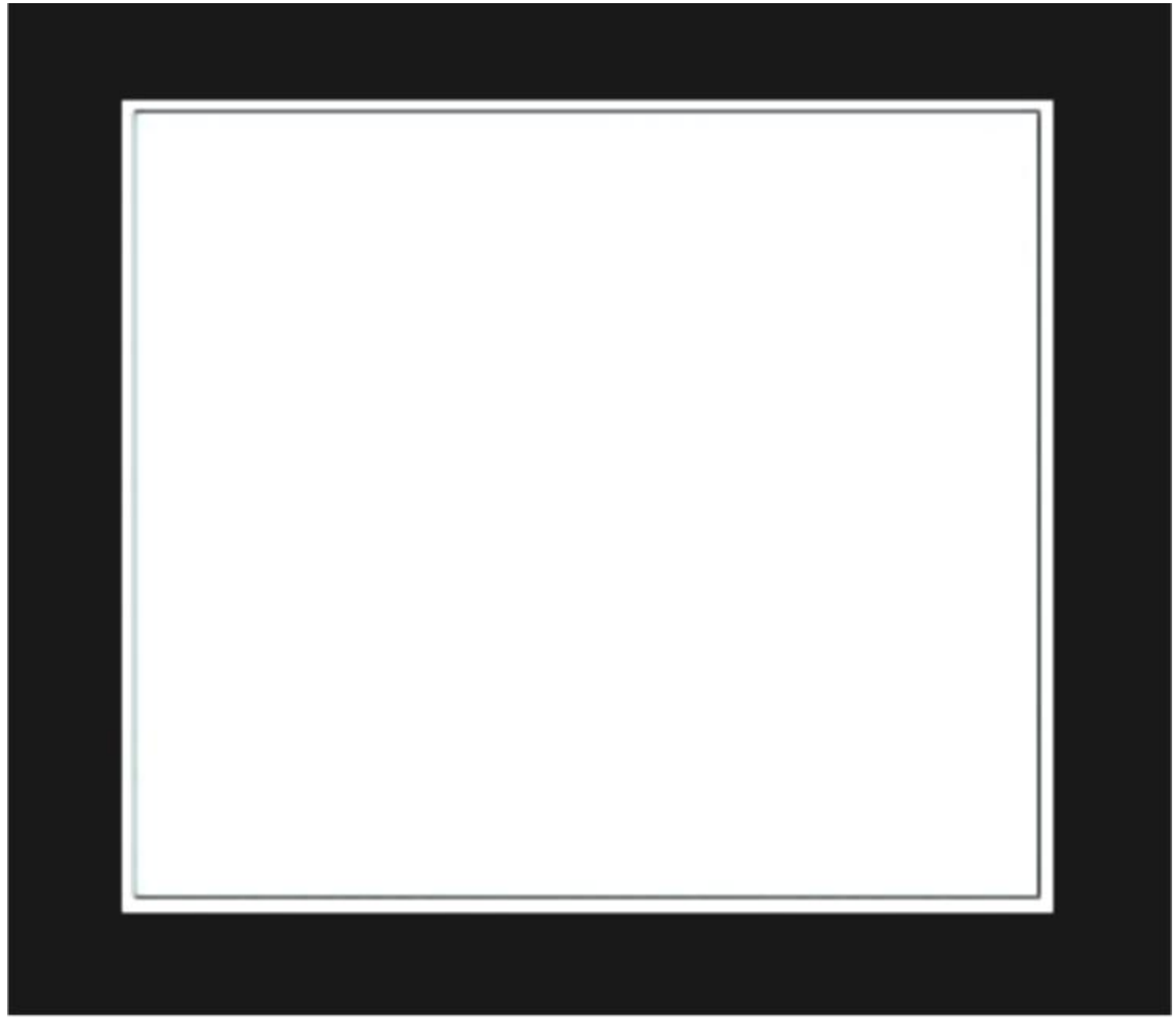
- Selective attention
  - With limited mental resources, only part of the stimulus field is being focused
  - Control what information is processed further
  - Information that passes through an attentional gate is transferred to short-term memory

- Sperling task (1960)



Sperling Task

- Sperling (1960)
  - Presented matrix of letters for 1/20th second
  - Report as many letters as possible

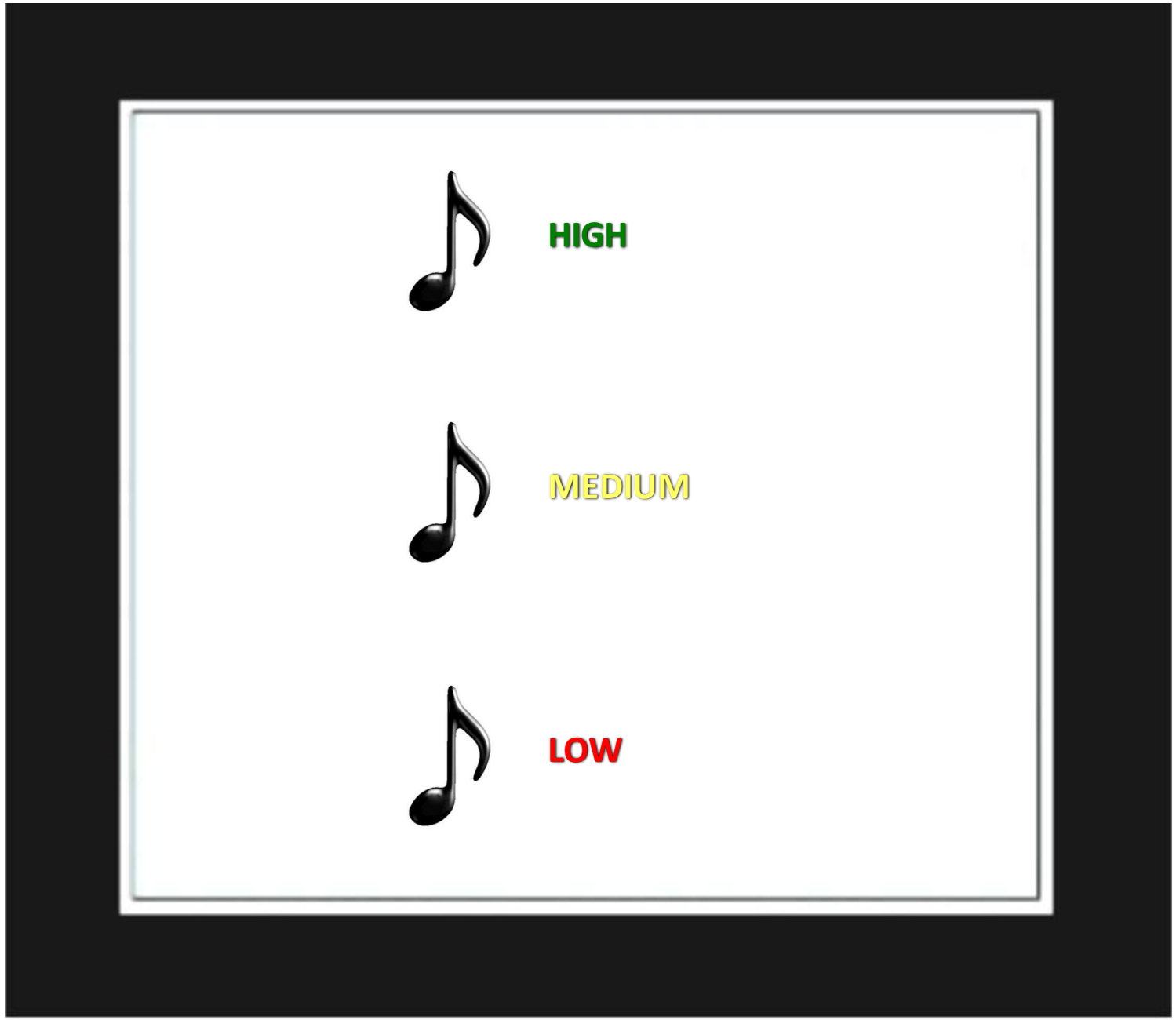


Sperling Task

- Sperling (1960)
  - Presented matrix of letters for 1/20th second
  - Report as many letters as possible

Sperling Task

- Sperling (1960)
  - Presented matrix of letters for 1/20th second
  - Followed by low, medium, or high tone
  - Tone signaled which row to report


HIGH
MEDIUM
LOW

Sperling Task

- Sperling (1960)
  - Presented matrix of letters for 1/20th second
  - Followed by low, medium, or high tone
  - Tone signaled which row to report
  - Recall was almost perfect

How’d they do that?

- **Visual sensory memory** (iconic memory)
  - Holds an image for about a second

- **Auditory sensory memory** (echoic memory)
  - Holds sound info from a few to several seconds

Three System Memory

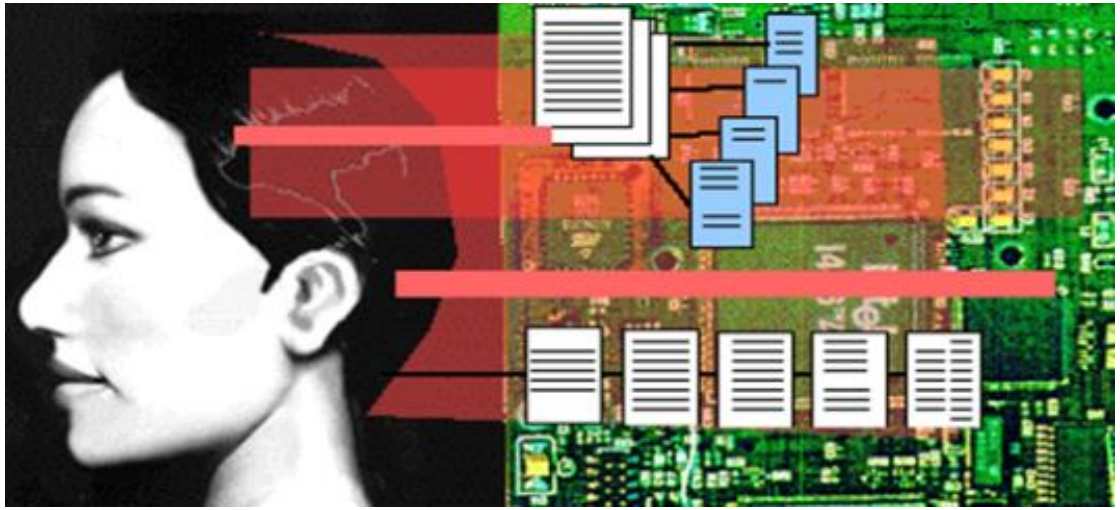
	Sensory Memory	Short-term Memory	Long-term Memory
Function	Temporary storage		
Span	High		
Duration	Less than 1 sec or a few sec		

Storage: Maintaining Memories Over Time

- There are three major kinds of memory storage:
  - Sensory memory
  - **Short-term memory (STM)** or working memory: storage that holds non-sensory information for more than a few seconds but less than a minute; can hold about 7 items
    - **Rehearsal**: the process of keeping information in STM by mentally repeating it
    - **Chunking**: combining small pieces of information into larger clusters that are more easily held in STM
    - **Working memory**: active maintenance of information in STM.
  - Long-term memory (LTM)

Short-term Memory

- Working memory
  - Helps to work with info held in short-term memory
  - Maintenance
    - Hold info in short-term memory
  - Manipulation
    - Work on that information



Short-term Memory

- Span
  - Immediate memory span: Max # of items you can recall perfectly after seeing once
  - Magic number: 7±2 (?) **meaningful** items
  - With new information coming, displacement or bumping out will happen
    - Interference – loss of info due to incoming, competing information
    - Decay – fading of info from memory over time
  - Enlarge Span?
    - Chunking and organization

Short-term Memory

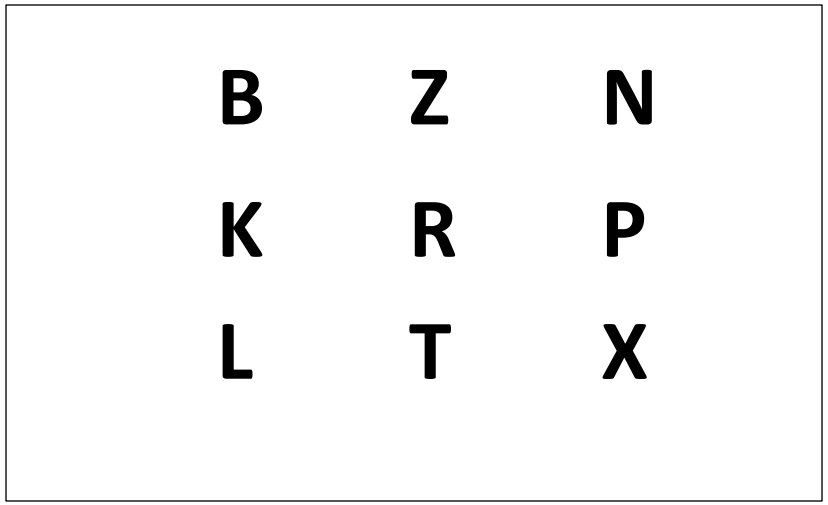
- Chunking and organization
  - GROUPINGBYMEANINGFULUNIT
    (Grouping by meaningful unit)
  - Increase the amount of information held in short-term memory

JFKCIAUSANBC

JFKCIAUSANBC

Short-term Memory

- Duration
  - Less than 20 sec without rehearsal
  - *Brown-Peterson task*
    - *A group of 3 letters presentation*
    - *Count backward by 3 from some number*



Short-term Memory

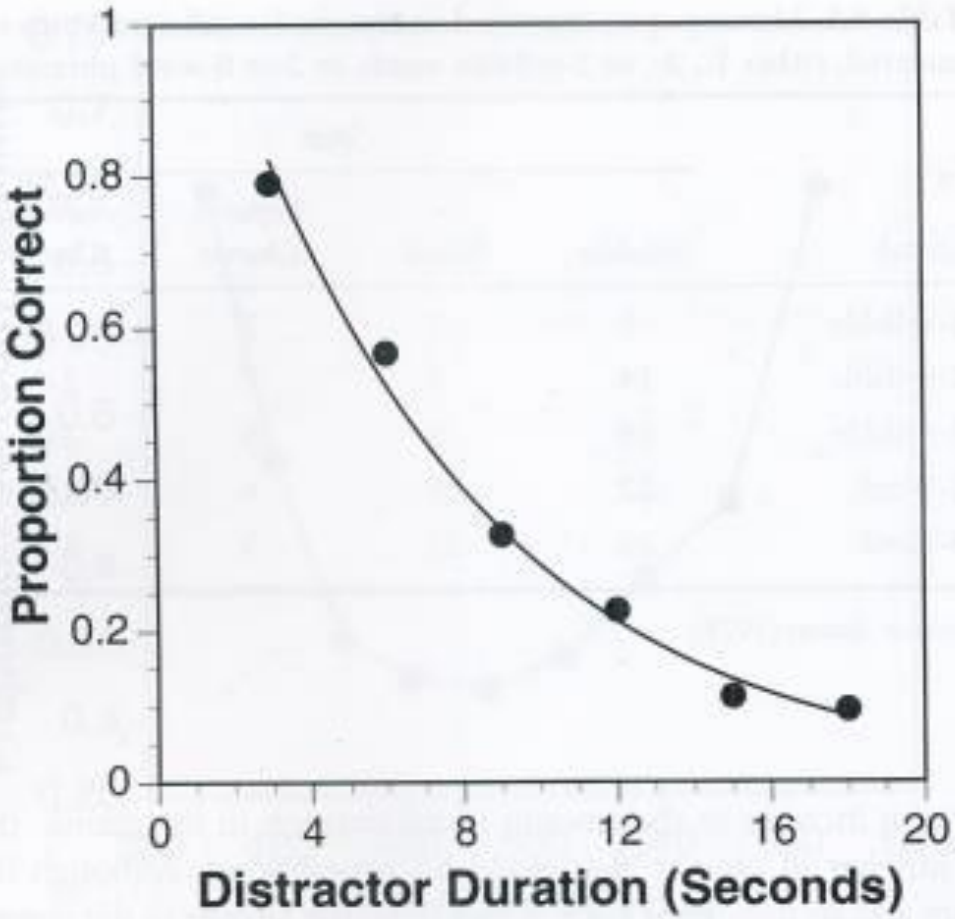


Figure 4.3 Proportion of consonant trigrams correctly recalled as a function of the distractor task duration. Source: Peterson & Peterson (1959).

Short-term Memory

- Brief storage of information currently being used
- Stores limited amount of info for limited time
- Duration: less than 20 sec

Three System Memory

	Sensory Memory	Short-term Memory	Long-term Memory
Function	Temporary storage of sensory info	Storage of info currently being used	
Span	High	Limited (*Chunking)	
Duration	Less than 1 sec or a few sec	Less than 20 sec	

Storage: Maintaining Memories Over Time

- There are three major kinds of memory storage:
  - Sensory memory
  - Short-term memory (STM)
  - **Long-term memory (LTM)**: storage that holds information for hours, days, weeks, or years; no known capacity

Long-term Memory

- The transfer of information between short-term and long-term memory
- Store information indefinitely
  - Maybe for a life time
- Permastore
  - May endure for decades

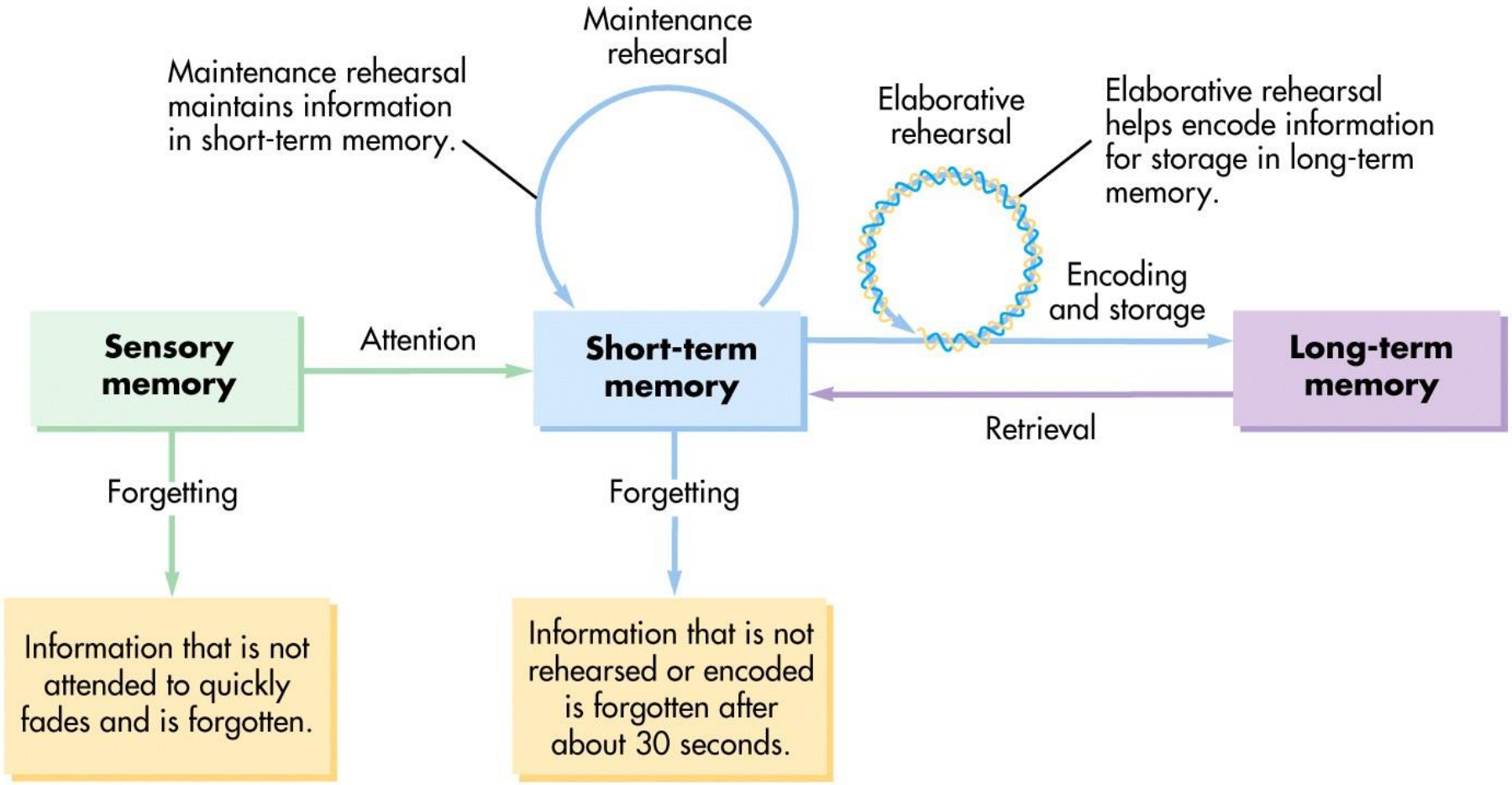
Long-term Memory

- Expectations affect what is recalled
  - Heard: The karate champion *hit* the cinder block
  - Remembered: The karate champion *broke* the cinder block
- Psychology: Science of Exceptions
  - Jill Price (40s) – recalls every daily event in great detail since 1980s
- Prone to distortion
  - Eyewitness testimony

Three System Memory

	Sensory Memory	Short-term Memory	Long-term Memory
Function	Temporary storage of sensory info	Storage of info currently being used	Storage of info indefinitely
Span	High	Limited (*Chunking)	Unlimited
Duration	Less than 1 sec or a few sec	Less than 20 sec	For a lifetime

Three System Memory



Insights from free recall memory performance

Are STM and LTM different systems? Do they contribute differentially to different memory tasks?

Study the following words

BRICK

COFFEE

PUPIL

PANTS

TREE

GLASS

SHIRT

BAT

WATCH

SKY

Test

- Recall the words in any order you like.

Primacy and Recency Effects

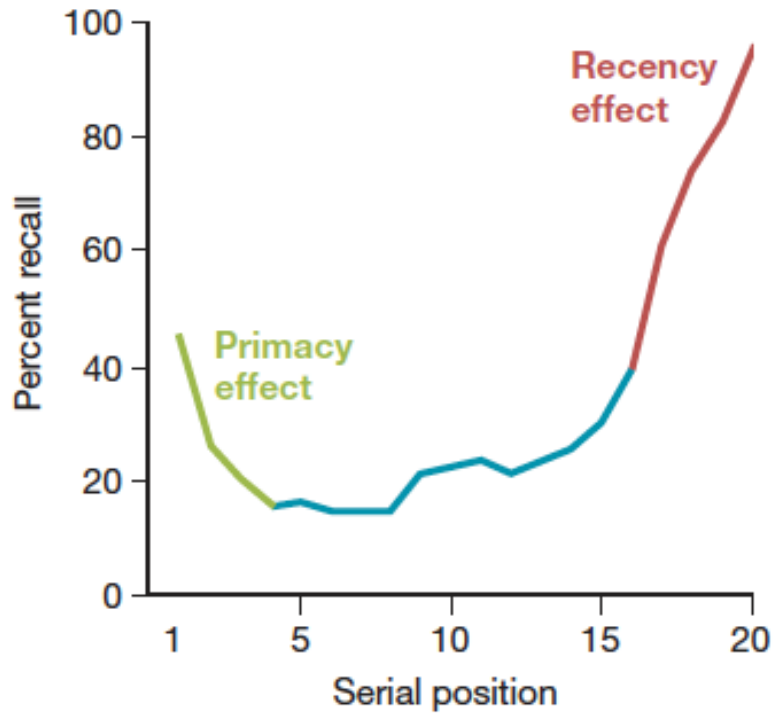


FIGURE 6.2 PRIMACY AND RECENCY EFFECTS IN FREE RECALL

Research participants in this study heard a list of 20 common words presented at a rate of one word per second. Immediately after hearing the list, participants were asked to write down as many of the words on the list as they could recall. The results show that position in the series strongly affected recall—participants had better recall for words at the beginning of the list (the primacy effect) and for words at the end of the list (the recency effect), compared to words in the middle of the list.

How do we explain primacy and recency effects?

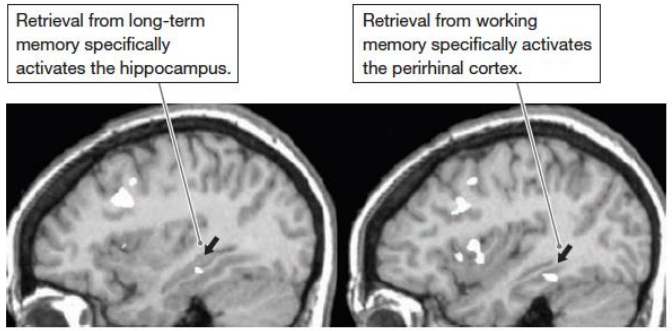
- Recency – output from working memory
- Primacy – more attention, rehearsal time

If primacy and recency are driven by two different memory "systems", it should be possible to manipulate them independently

Add a distractor task at the end of the study list = "delayed free recall" with a "filled delay".

Serial position curve of a distractor-filled delayed free recall task compared to immediate free recall or unfilled delay period

FIGURE 6.5 BRAIN REGIONS SUPPORTING WORKING MEMORY AND LONG-TERM MEMORY



We can confirm the distinction between working memory and long-term memory with fMRI scans. These scans suggest that memory for early items on a list depends on brain areas (in and around the hippocampus) that are associated with long-term memory; memory for later items on the list do not show this pattern. (TALMI, GRADY, GOSHEN-GOTTSTEIN, & MOSCOVITCH, 2005)

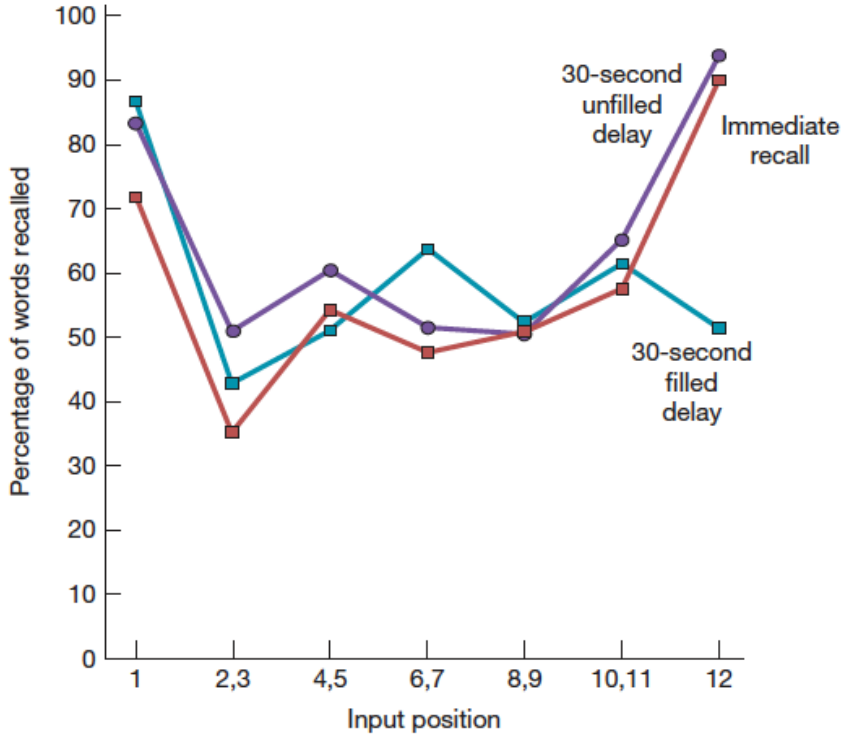


FIGURE 6.3 THE IMPACT OF INTERPOLATED ACTIVITY ON THE RECENCY EFFECT

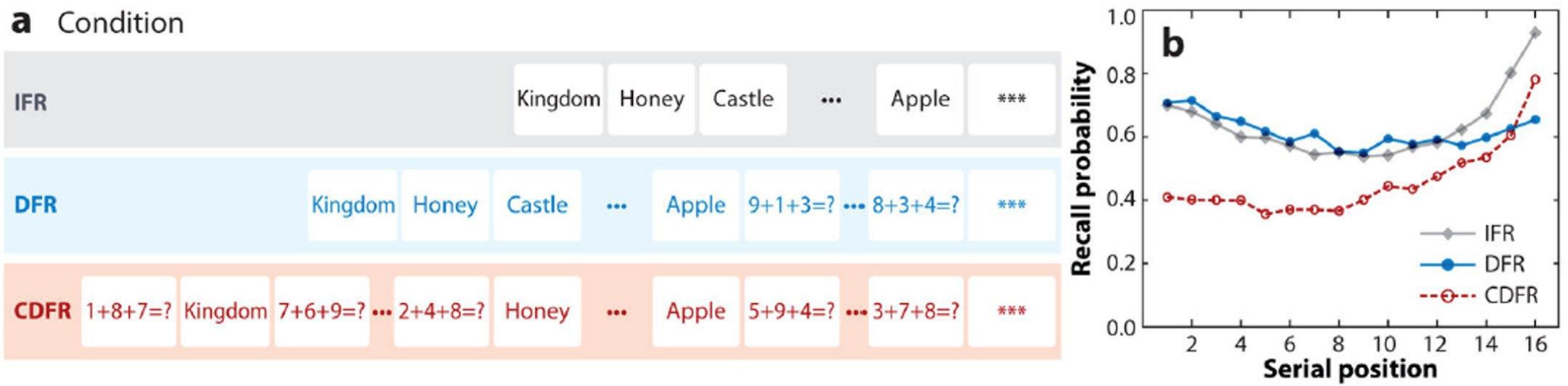
With immediate recall (the red line in the figure), or if recall is delayed by 30 seconds with no activity during the delay (the purple line), a strong recency effect is detected. In contrast, if participants spend 30 seconds on some other activity between hearing the list and the subsequent memory test (the blue line), the recency effect is eliminated. This interpolated activity has no impact on the pre-recency portion of the curve (i.e., the portion of the curve other than the last few positions).

Interim conclusions from recency effects

- Recency --> driven by items held in working memory which are easier to access, so they get recalled first.
- Disappears when you introduce a filled delay period.
- Open and shut case?

Think again: long-term recency effects!

- Why do we get recency effects in a continuous-distractor free-recall task?! Not covered in the text book.

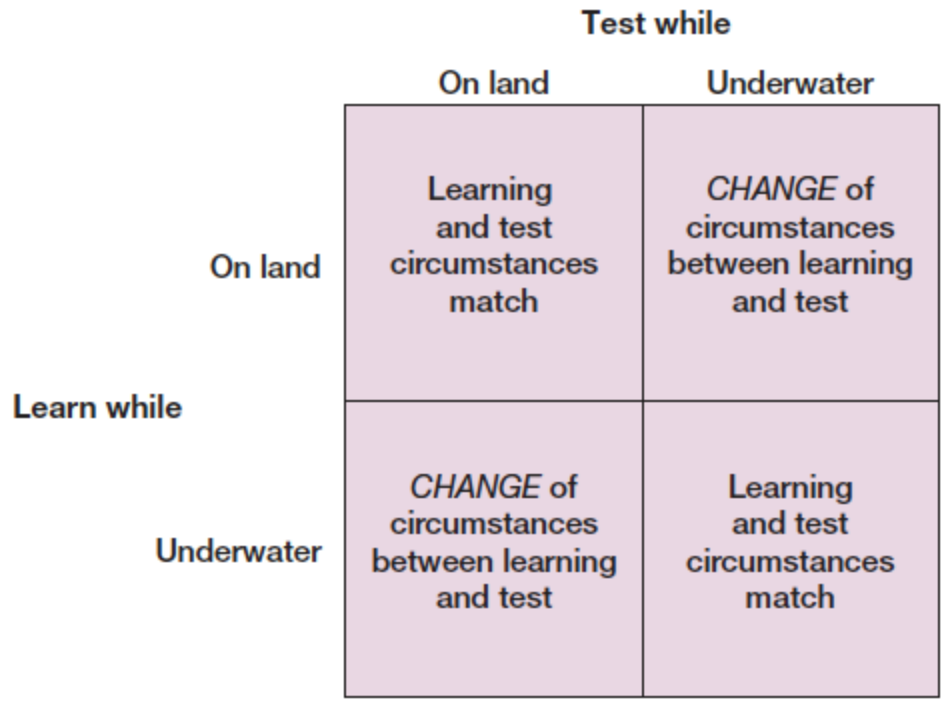


The role of context

Godden & Baddeley, 1975

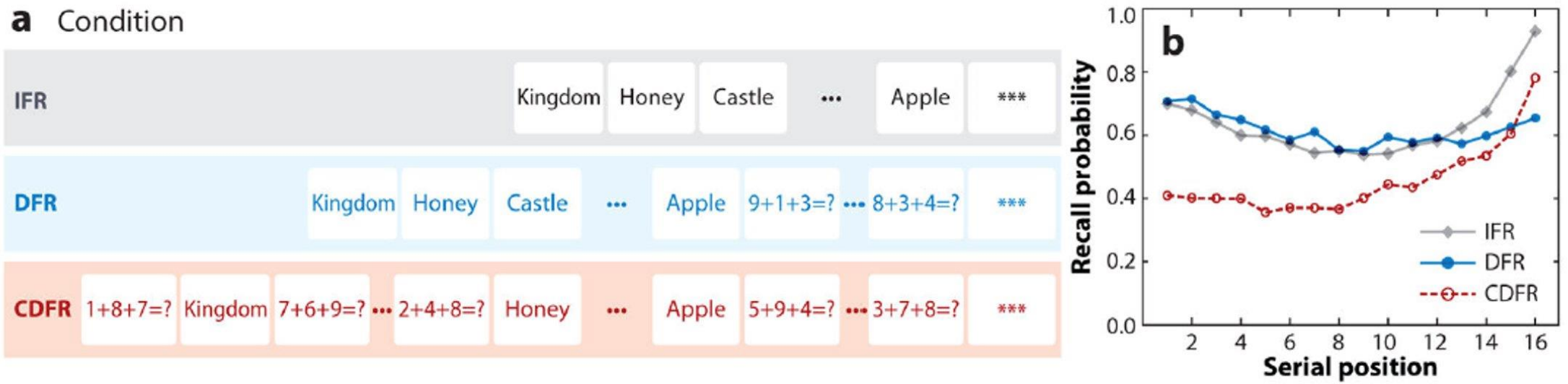
FIGURE 7.2 THE DESIGN OF A CONTEXT-DEPENDENT LEARNING EXPERIMENT

Half of the participants (deep-sea divers) learned the test material while underwater; half learned while on land. Then, within each group, half were tested while underwater; half were tested on land. We expect a retrieval advantage if the learning and test circumstances match. Therefore, we expect better performance in the top left and bottom right cells.



Similarity of testing context to study context matters

- Now, think again about long-term recency effects



The testing context is most similar to the study context at the end of the list, if you assume that context is something that changes very gradually

- This is where we'll stop as it is not possible to get into more details about the mystery on the previous slide in one lecture. However, those of you who are curious can email me to get some reading material to dig deeper into the mystery.

Temporal Context Model (TCM)

Gradually changing temporal context during experience

A

B

C

D

***

ABC

Recovery of temporal context during re-experience

E

F

C

ABC

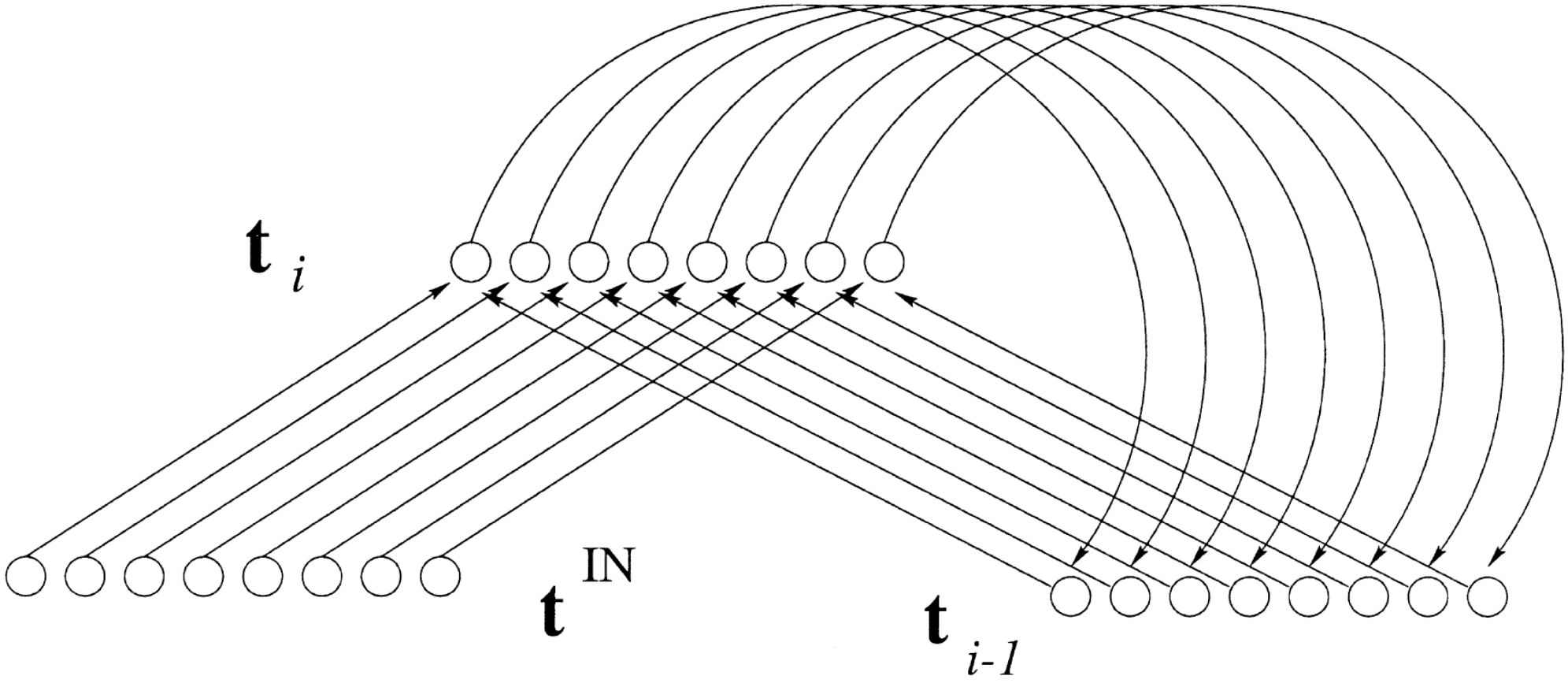
Retrieved temporal context

Current temporal context

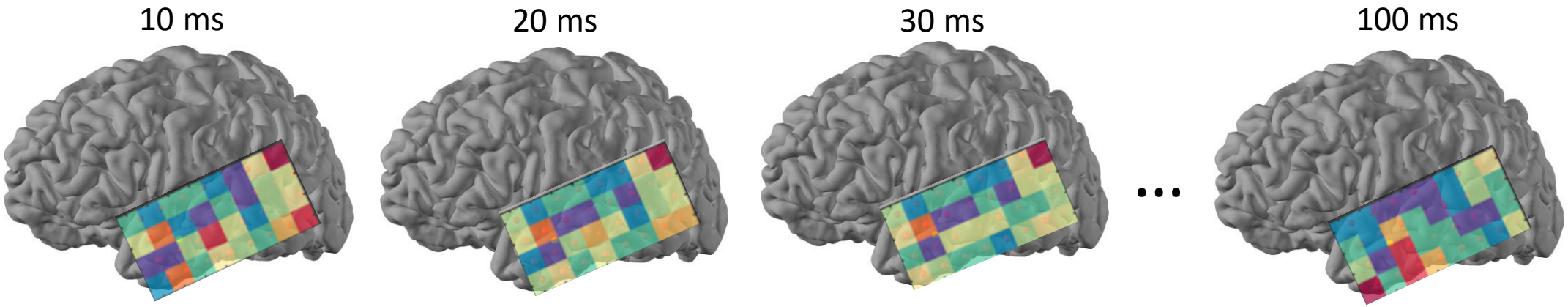
EFC

Oh no! Man get fruit NOW or man die!

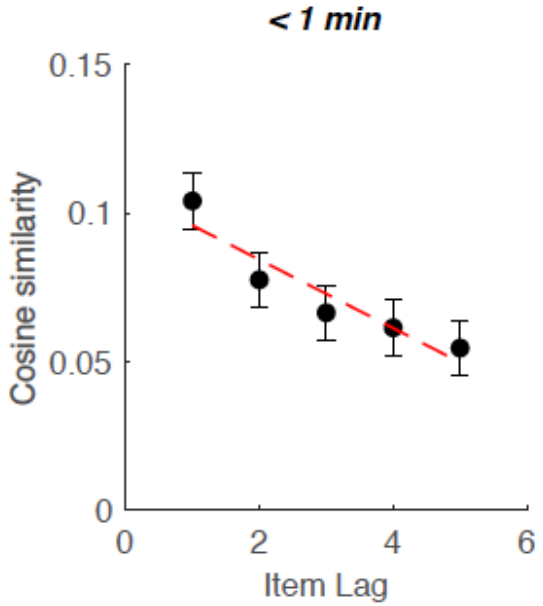
Slowly varying temporal context as a RNN

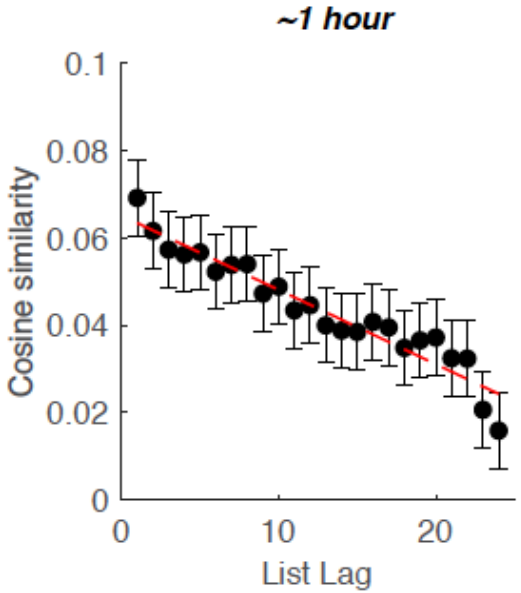


Context representations changing over time



N = 31





Sreekumar, Swift, Kaplan, El-Kalliny, Inati, & Zaghloul, *In Prep*

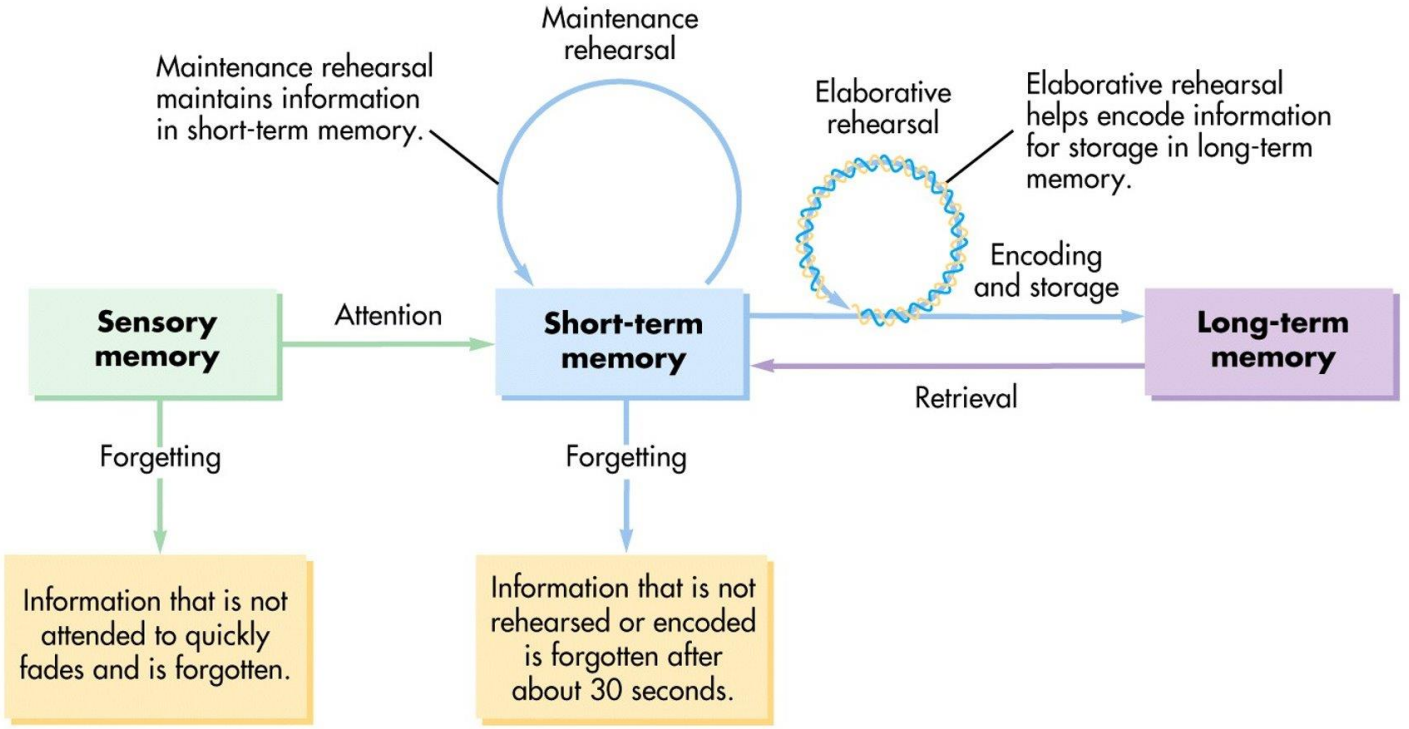
If context similarity is the explanation, why is recency attenuated in delayed free recall but not continuous distractor free recall?

- Both tasks have the same delay after the last item
- A potential answer: free recall retrieval is a competitive retrieval: competition amongst items. So the more distinctive the items are, the better they can be recalled. Continuous distractors make the last items (most recent) distinctive. So, there is an added benefit of distinctiveness, explaining recency effects in CDFR but not in DFR.
- Compare test context match with last item and test context match with other items: a greater difference for CDFR, explaining long-term recency effects.
- So a short term memory buffer by itself cannot explain all recency effects in free recall because it cannot explain this difference in recency between DFR and CDFR.

So is our dual store model of memory correct?

- Is there really such a big difference between STM and LTM or should we instead focus on common principles (such as distinctiveness, context-based retrieval) that can explain phenomena across different tasks and conditions?
- This is an open debate..

A few quick notes about how information might move from working memory to more long-term storage

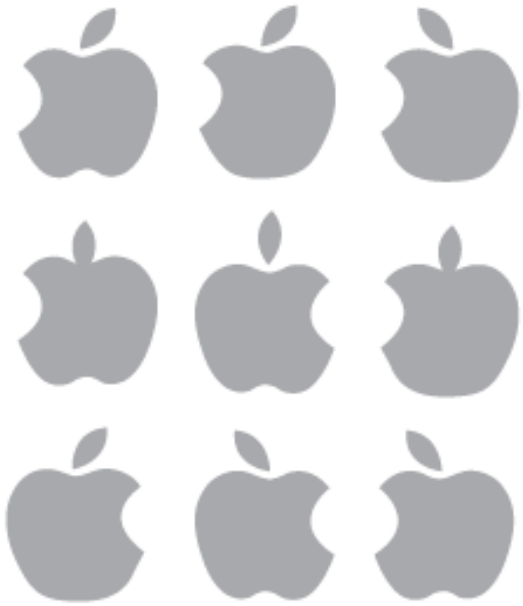


Multiple passive exposures are insufficient

FIGURE 6.10 MEMORY FOR AN OFTEN-VIEWED LOGO

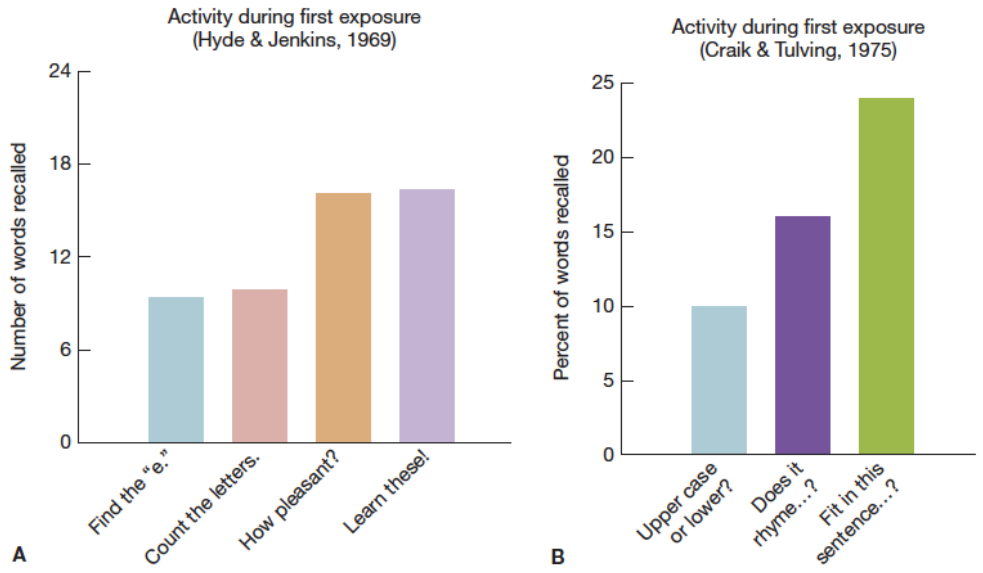
Most people have seen the Apple logo countless times, but they've had no reason to pay attention to its features. As a result, they have poor memories for the features. Test yourself. Can you find the correct version among the options displayed here?

(THE ANSWER IS AT THE END OF THE CHAPTER.)



The need for active and deep encoding

FIGURE 6.12 THE IMPACT OF DEEPER PROCESSING



The two sets of results shown here derive from studies described in the text, but they are part of an avalanche of data confirming the broad pattern: Shallow processing leads to poor memory. Deeper processing (paying attention to meaning) leads to much better memory. And what matters seems to be the level of engagement; the specific intention to learn (because participants know their memory will be tested later on) contributes little.

Other techniques to improve LTM

SPACED REPETITION

TESTING EFFECT

HOW WOULD YOU APPLY THIS TO PREPARE FOR EXAMS?

Brain activity when you correctly remember

Univariate analysis

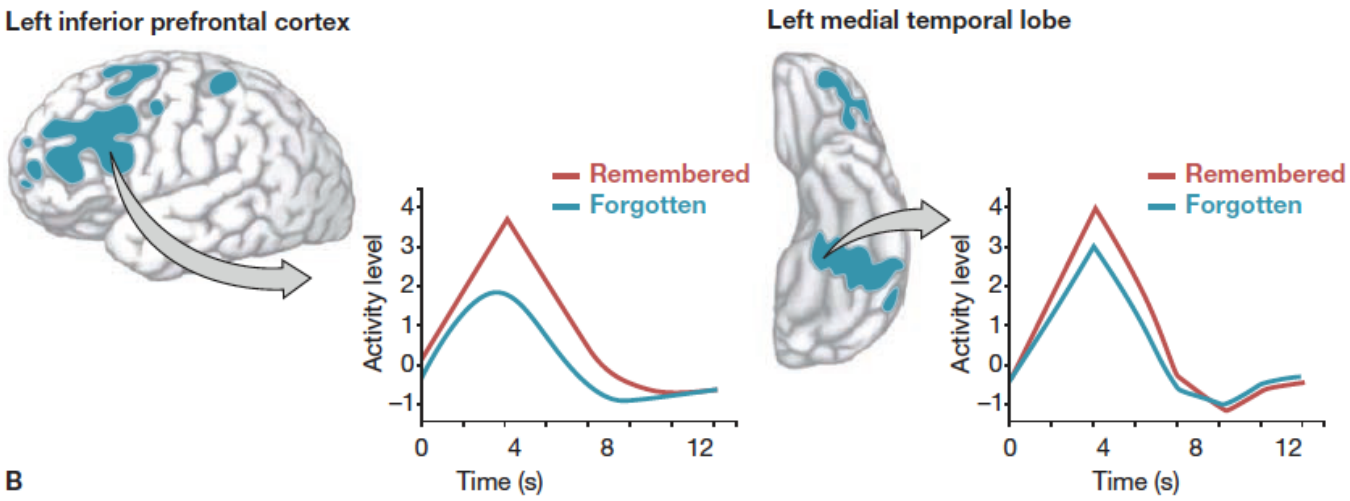
FIGURE 6.11 BRAIN ACTIVITY DURING LEARNING

Learn a series of words, and, during learning, record the neural response to each word.

Test memory for the words.

Based on what happened at Time 2, go back and examine the data from Time 1, looking separately at what happened during learning for words that were later remembered, and what happened during learning for words that were later forgotten.

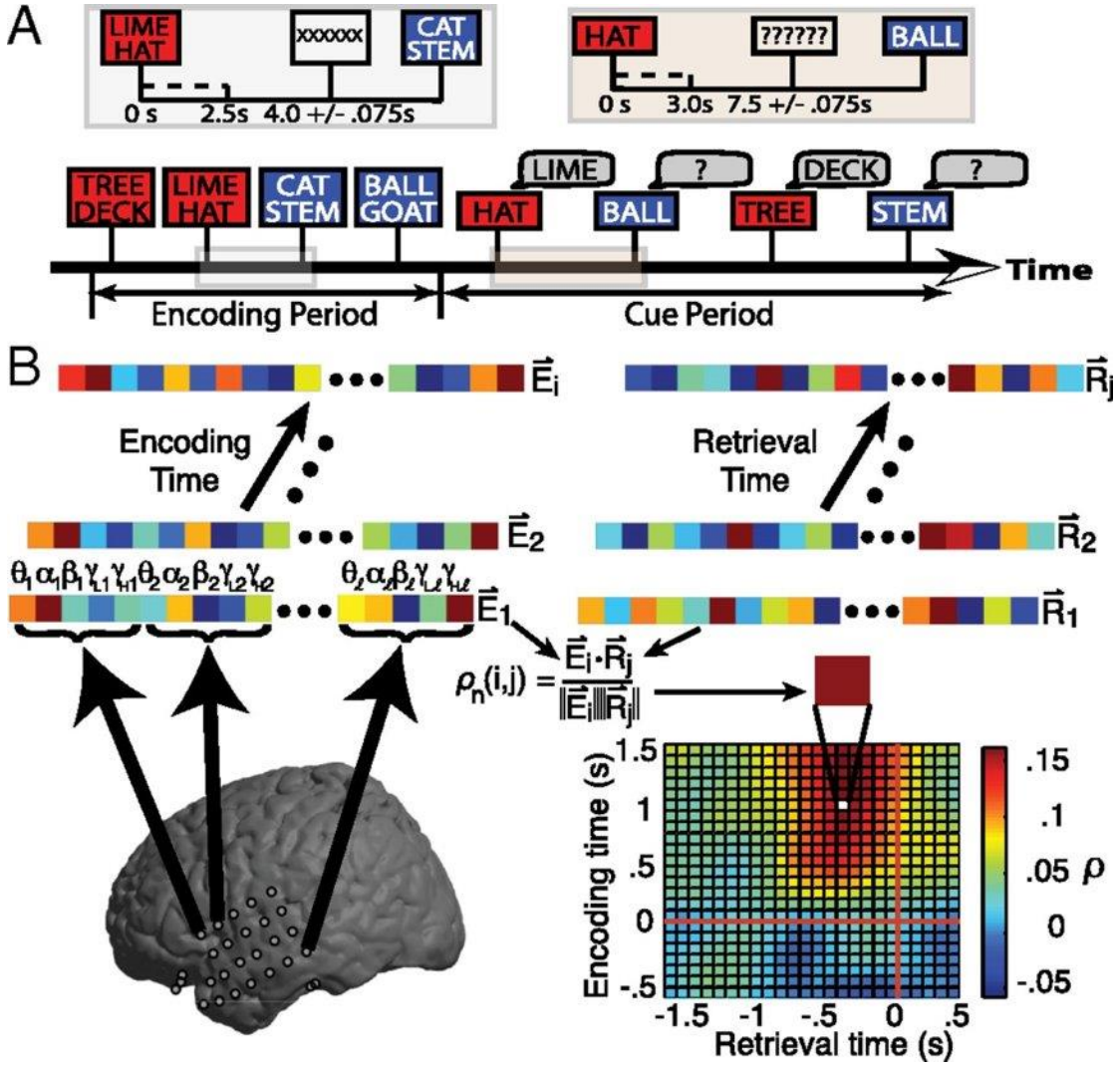
A



B

Brain activity when you correctly remember

Multivariate analysis

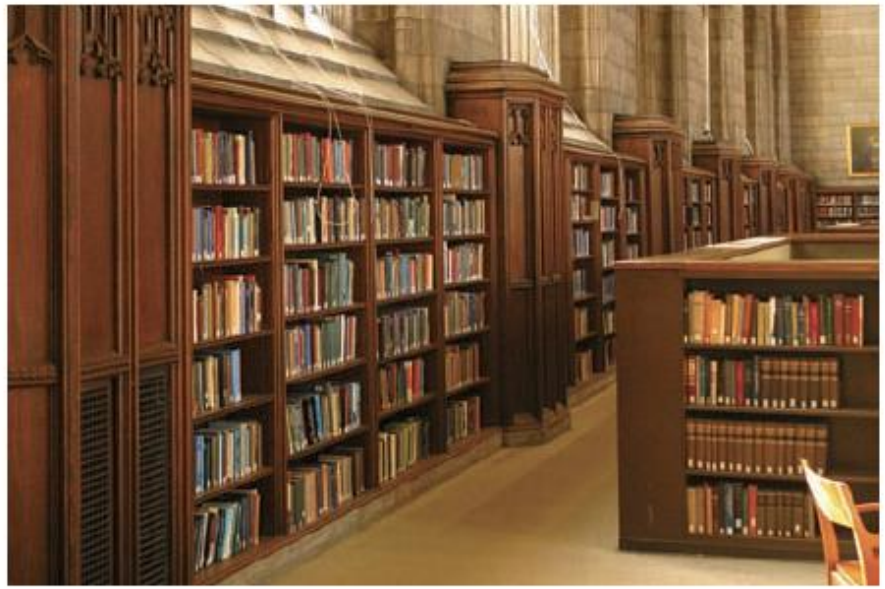


Robert B. Yaffe et al. PNAS 2014;111:52:18727-18732

The role of "connections" - memory cues

Why does spaced repetition enhance LTM?

Context cues and making different ones?



WHY DO MEMORY CONNECTIONS HELP?

When books arrive in a library, the librarians must catalogue them. This doesn't facilitate the "entry" of books into the library, because the books are in the building whether they're catalogued or not. But cataloguing makes the books much easier to find later on. Memory connections may serve the same function: The connections don't "bring" material into memory, but they do make the material "findable" in long-term storage later.

Using "connections" as a memory strategy

FIGURE 6.14 MNEMONIC STRATEGIES

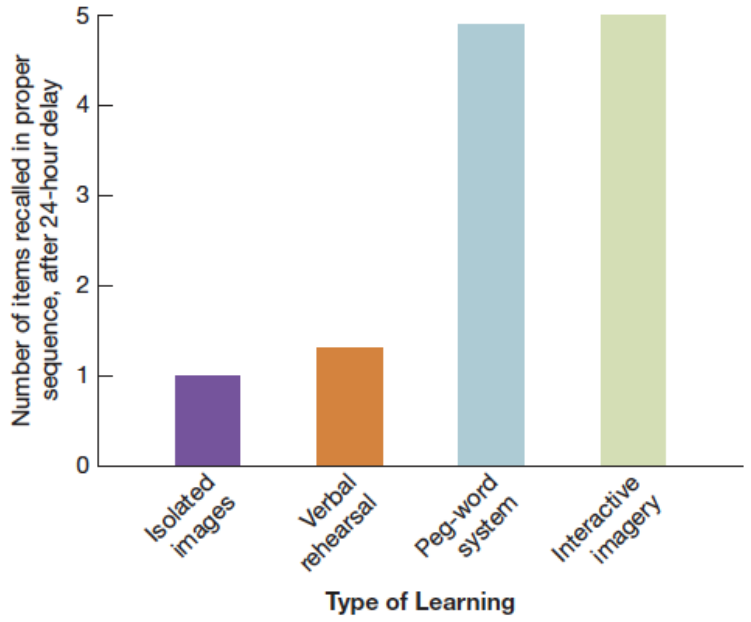
With a bit of creativity, you can make up mnemonics for memorizing all sorts of things. For example, can you name all ten of the Canadian provinces? Perhaps there is a great mnemonic available, but in the meantime, this will do. It's a complicated mnemonic but unified by the theme of the early-morning meal: "**B**reakfast **C**ooks **A**lways **S**ell **M**ore **O**melets. **Q**uiche **N**ever **B**ought; **N**ever **S**old. **P**erhaps **E**ggs **I**n **N**ew **F**orms?" (You're on your own for remembering the three northern territories.)

"Peg words"

One is a bun.
Two is a shoe.
Three is a tree.
Four is a door.
Five is a hive.
Six are sticks.
Seven is heaven.
Eight is a gate.
Nine is a line.
Ten is a hen.

Mnemonics are powerful memory aids

FIGURE 6.15 THE POWER OF MNEMONICS



Mnemonics can be enormously effective. In this study, students who had relied on peg words or interactive imagery vastly outperformed students who'd used other memorizing strategies. (AFTER ROEDIGER, 1980)

Memorization vs Understanding

- All the prior discussion was only about what improves memory.
- Rote memory however does not imply you will be able to use the information you learned in novel situations.
- Understanding is not the same as memorization.
- Understanding comes also from using connections! You have to be actively engaged, constantly trying to make connections to your existing knowledge but also to other new information that you get.

So is spaced repetition testing the best way for you to study?

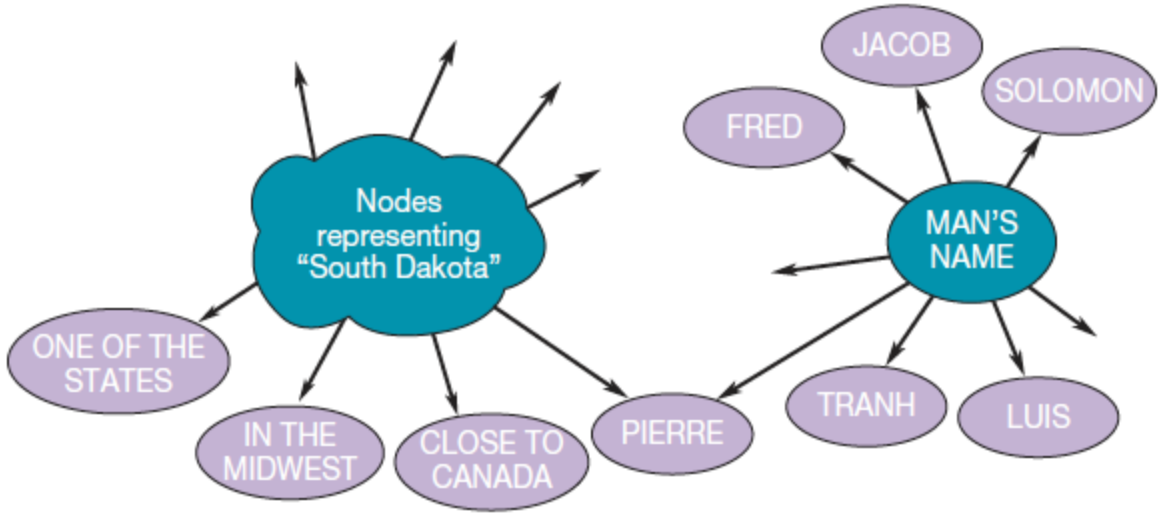
- Well, it will depend on what kind of test it is!
- Going to test your memory?
- Going to test how you can apply the material to novel situations?

Next:

- More on cues, retrieval, etc.
- Remembering complex events: Episodic memory; Autobiographical memory.

Spreading Activation

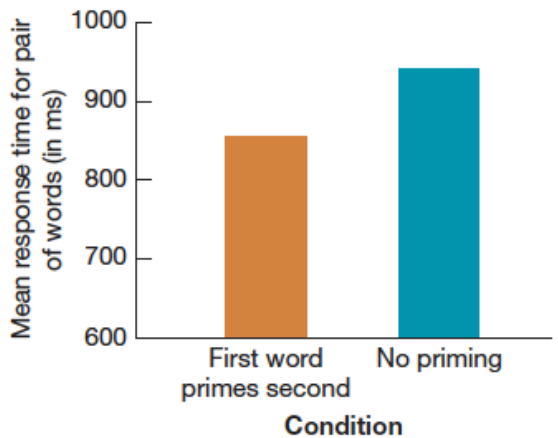
FIGURE 7.5 ACTIVATION OF A NODE FROM TWO SOURCES



Semantic Priming

- Lexical decision-making
- Pair of words
- CAKE SHOE
- BREAD BUTTER

FIGURE 7.6 SEMANTIC PRIMING



Participants were given a lexical-decision task involving pairs of words. In some pairs, the words were semantically related (and so the first word in the pair primed the second); in other pairs, the words were unrelated (and so there was no priming). Responses to the second word were reliably faster if the word had been primed—providing clear evidence of the importance of subthreshold activation.

(AFTER MEYER & SCHVANEVELDT, 1971)

Familiarity vs recollection

"FAMILIAR . . . BUT *WHERE DO I KNOW HIM FROM?!?*"

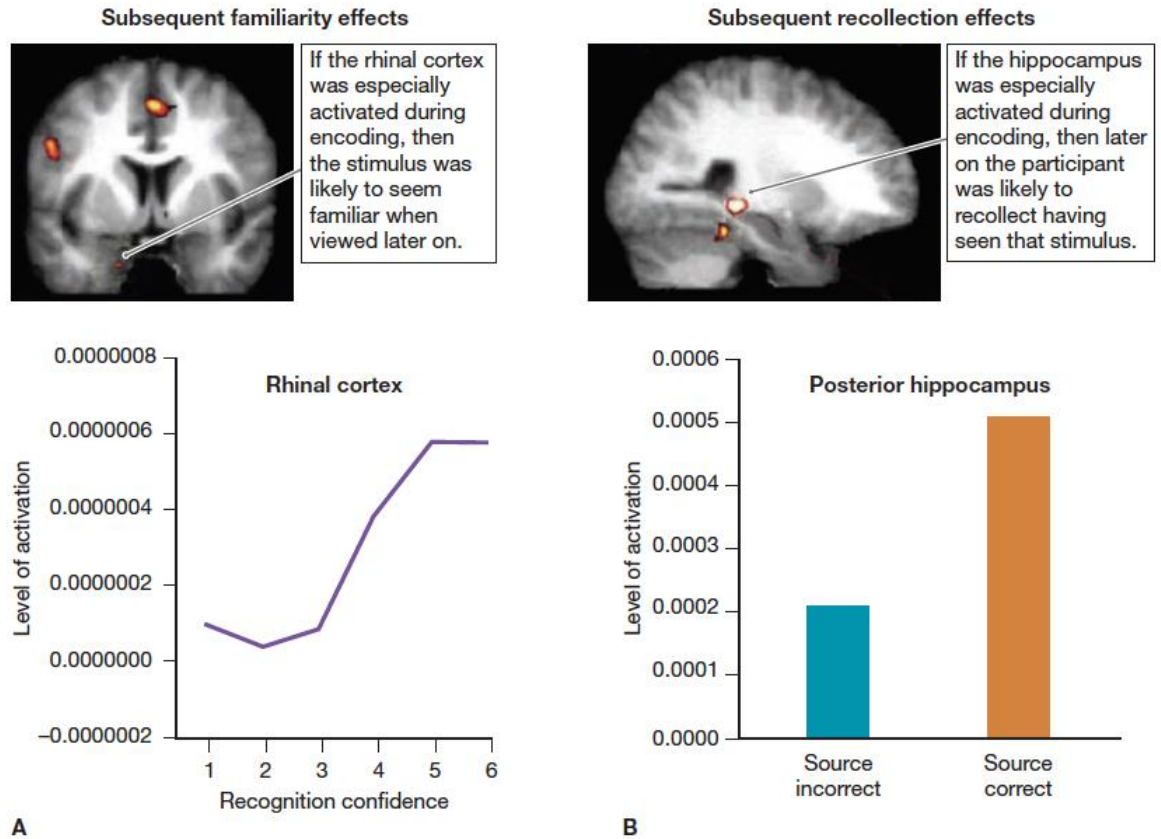
Recognition Memory

- Thought to rely on a memory strength signal
- Signal Detection Theory applies
- Can have familiarity without source memory (Remember/Know judgments)

Can you have source memory without a familiarity signal?!

- Capgras syndrome
- Detailed recollection of when you met your family last, what they look like, etc.
- When they are around however and in view, they feel strangely unfamiliar..

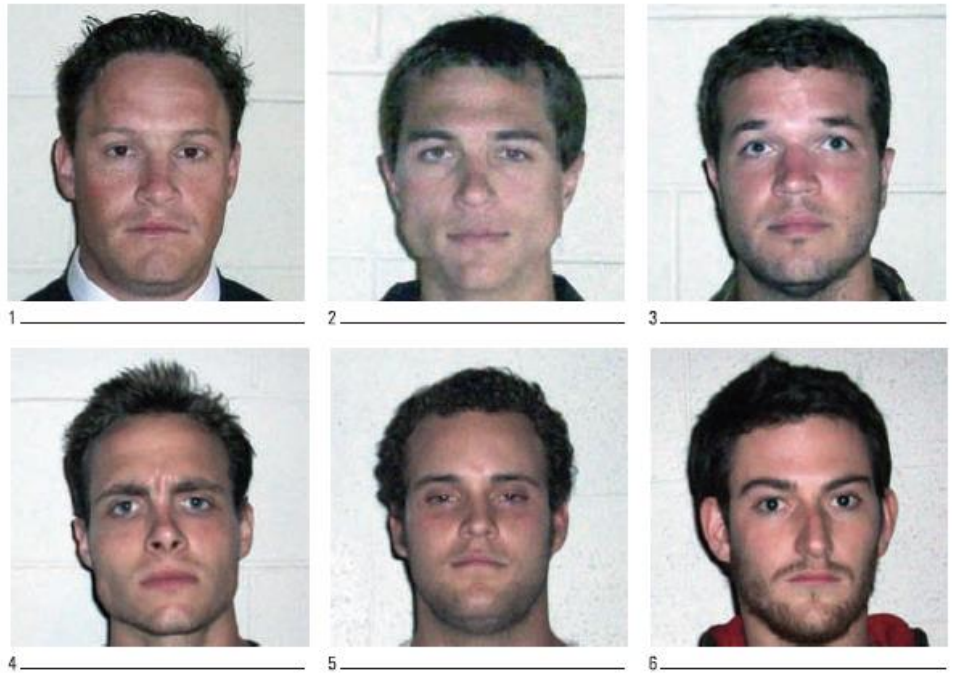
FIGURE 7.7 FAMILIARITY VERSUS SOURCE MEMORY



Familiarity vs source memory

FIGURE 7.8 A PHOTO LINEUP

Middletown Police Department Lineup ID: 24601 20 Mar 2009



1 2 3

4 5 6

FOR OFFICIAL USE ONLY

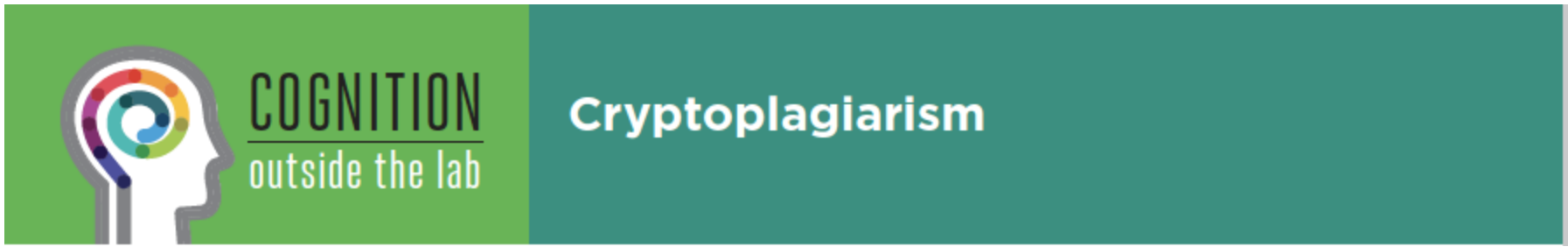
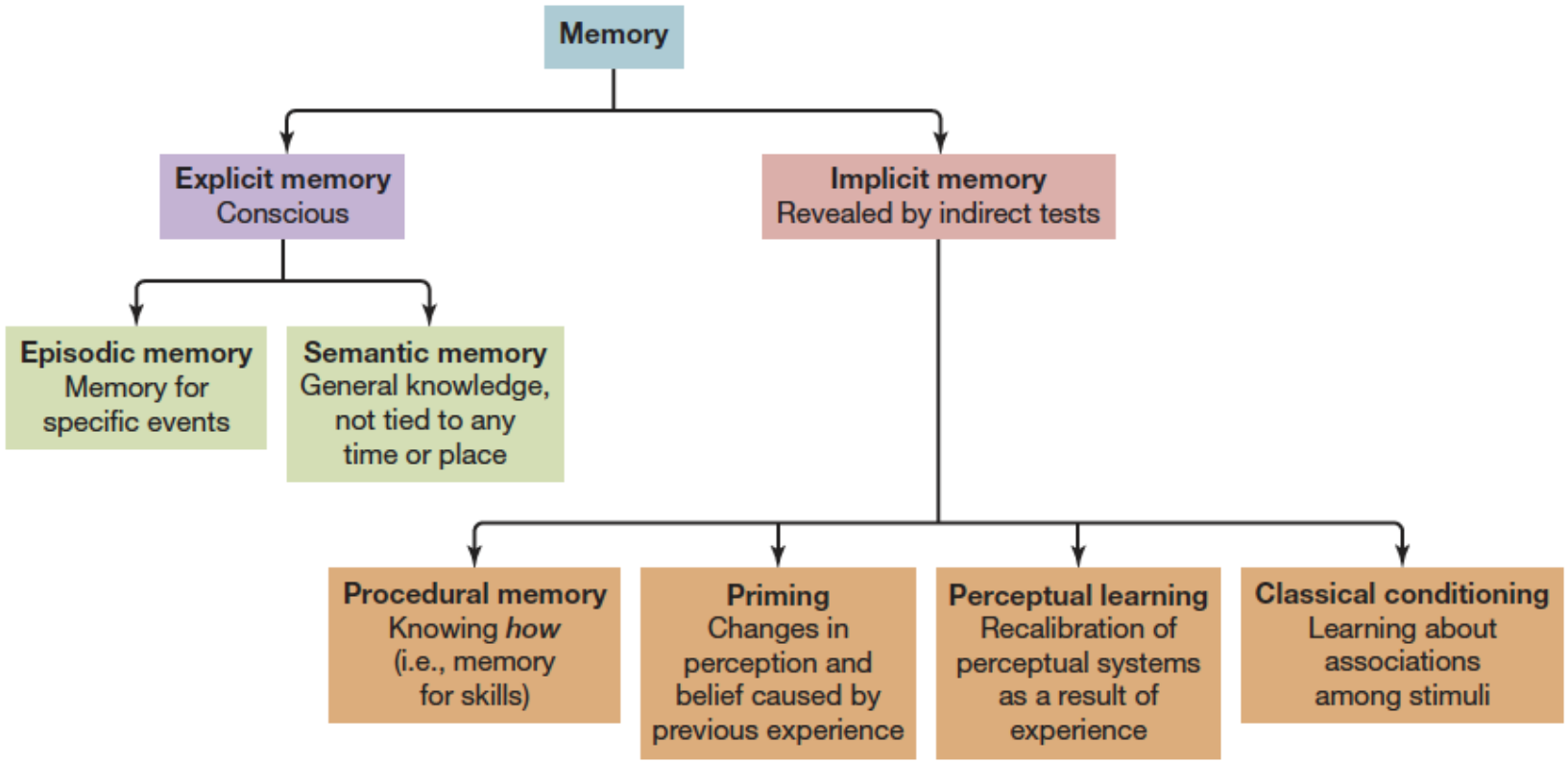

COGNITION
outside the lab
Cryptoplagiarism

FIGURE 7.11 HIERARCHY OF MEMORY TYPES



In our discussion, we've distinguished two types of memory—explicit and implicit. However, there are reasons to believe that each of these categories must be subdivided further, as shown here. Evidence for these subdivisions includes functional evidence (the various types of memory follow different rules) and biological evidence (the types depend on different aspects of brain functioning).

FIGURE 7.13 SEMANTIC MEMORY WITHOUT EPISODIC MEMORY

Kent Cochrane—known for years as "Patient K.C."—died in 2014. In 1981, at age 30, he skidded off the road on his motorcycle and suffered substantial brain damage. The damage caused severe disruption of Cochrane's episodic memory, but it left his semantic memory intact. As a result, he could still report on the events of his life, but these reports were entirely devoid of autobiographical quality. In other words, he could remember the bare facts of, say, what happened at his brother's wedding, but the memory was totally impersonal, with no recall of context or emotion. He also knew that during his childhood his family had fled their home because a train had derailed nearby, spilling toxic chemicals. But, again, he simply knew this as factual material—the sort of information you might pick up from a reference book—and he had no recall of his own experiences during the event.

Hypnosis? Repressed memories?

A Drawings done by hypnotized adult told that he was 6 years old

B Drawings done at age 6

Why do we make memory errors?

FIGURE 8.1 THE OFFICE USED IN THE BREWER AND TREYENS STUDY

No books were in view in this office, but many participants, biased by their expectations of what should be in an academic office, remembered seeing books.

(AFTER BREWER & TREYENS, 1981)

A brief history of rigorous memory studies

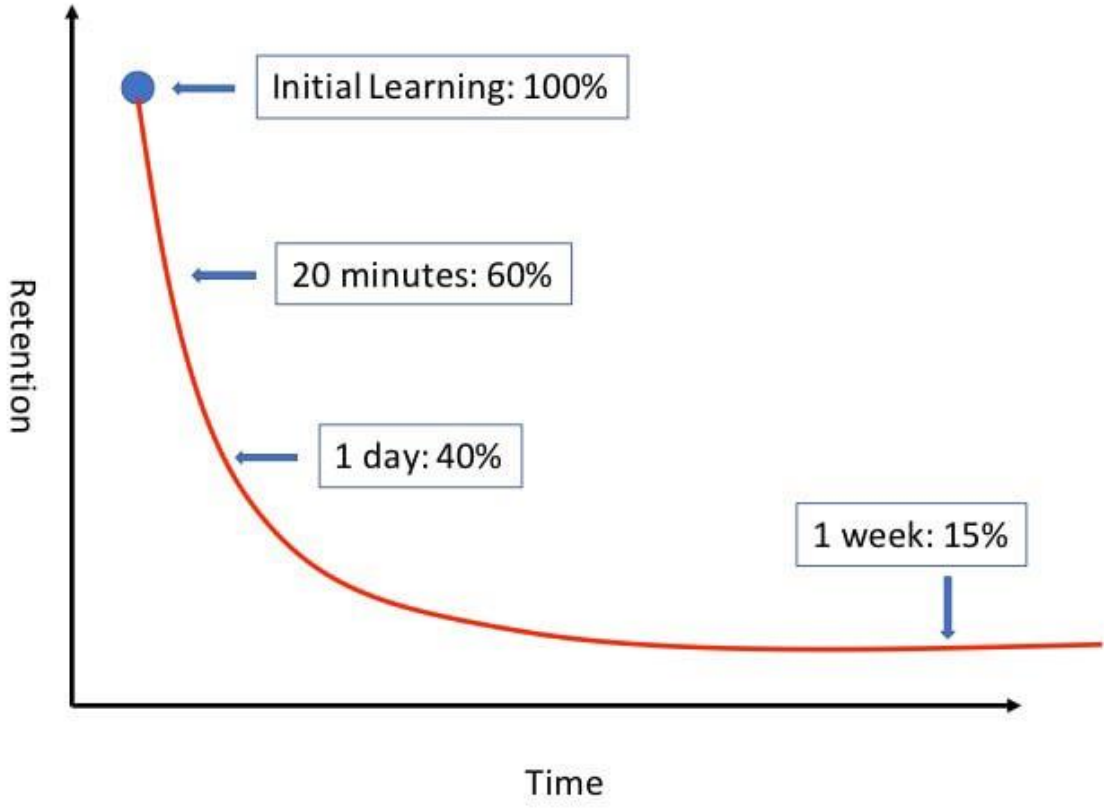


Figure 1.1 The humble beginnings of a science. Cartoon of Hermann Ebbinghaus learning a list of syllables (Courtesy of S. Polyn, illustrator).

Insights from Ebbinghaus (late 1800's)

- Spaced learning > massed learning
- Attention varies over trials
- Short term memory span
- Associations between contiguous items
- Remote associations!
- List 1: A1 A2 A3 ….
- List 2: A1 A3 A5 …. A2 A4 A6 …

Georg Elias Muller

Developed paired-associates learning.

Introduced the notion of interference as being important.

Introduced methodological rigor in memory science

In the next 20 years, ~50 papers published on memory

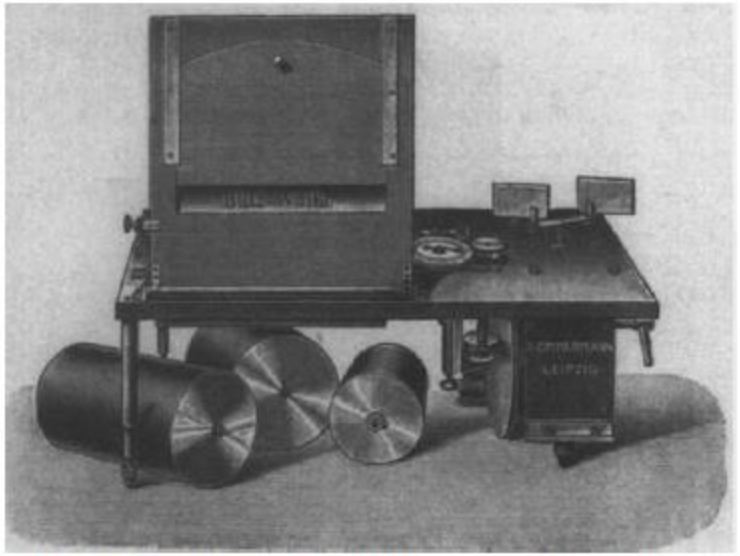


Figure 1.2 Early memory drum. An early memory drum, based on the design of Müller. Circa 1900.
Source: Zimmermann, E. (1903). XVIII. Preis- Liste über psychologische und physiologische Apparate (p. 13). Leipzig: Eduard Zimmermann.

Introspection vs Objective measurements

Wundt: introspection

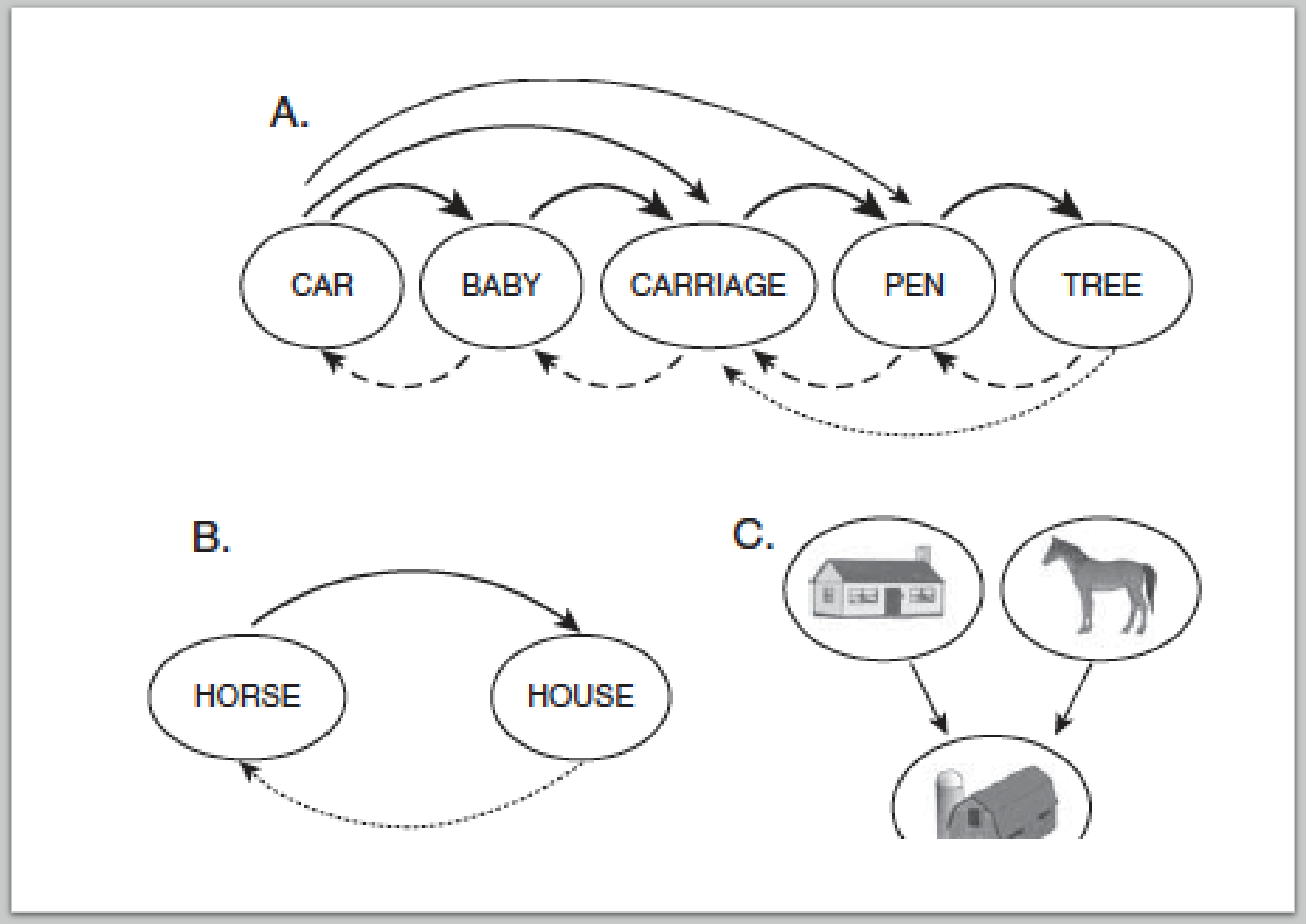
Muller et al: objective rigorous methods

Introspection

FEELING OF FAMILIARITY WITHOUT REALLY KNOWING SOURCE DETAILS...

CAN BE VALUABLE AS WELL.

Classic view of associations



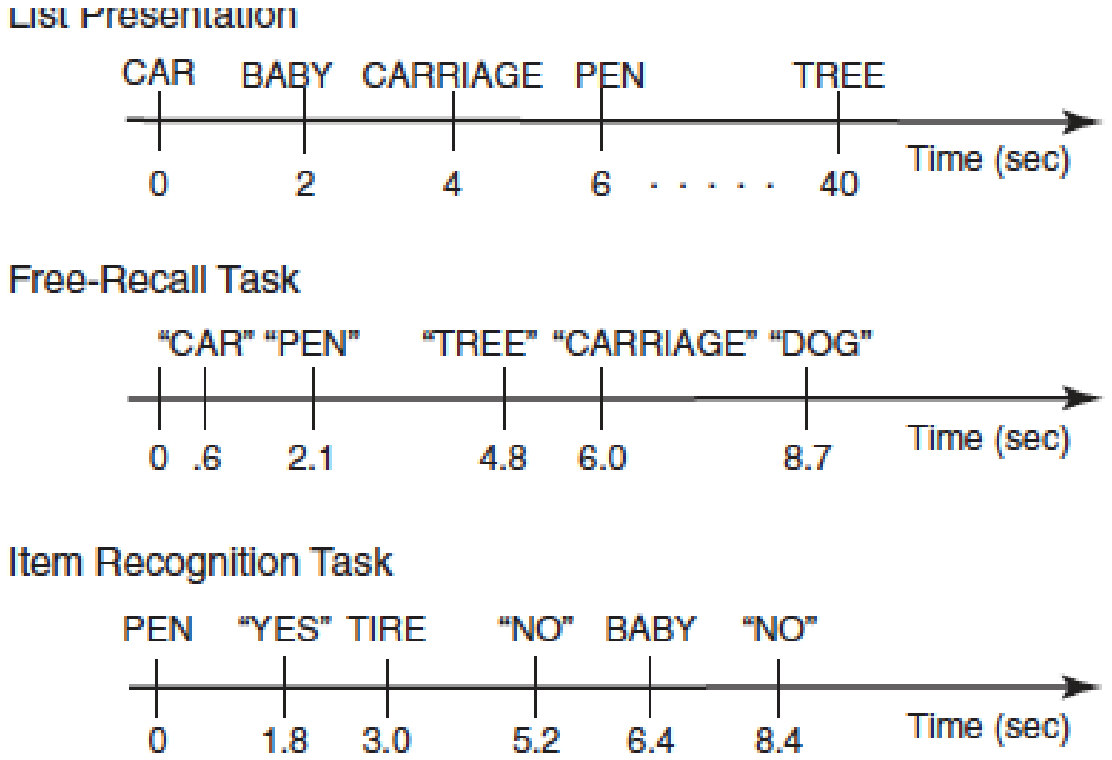


Figure 1.4 Recall and recognition tasks. Top: timing of item presentation. Middle: sample responses during a free-recall task. Bottom: sequence of test probes and *yes-no* responses in an item-recognition test. The words *pen* and *baby* appeared on the studied list, whereas the word *tire* had not. Quotes denote participants' responses.

Typical lab tasks

Real-world autobiographical memories?

Can we study them rigorously?