Section 4: Memory

Iconic and Short-Term Memory

Memory

- Why are some things easy to remember?
- Why are some things difficult to remember?
- Are there such things as repressed memories?
- Are there effective techniques for retrieving "forgotten" memories?
- What about Amnesia? Do these people really have years of memories lost forever? What can they remember?

Types of Memories

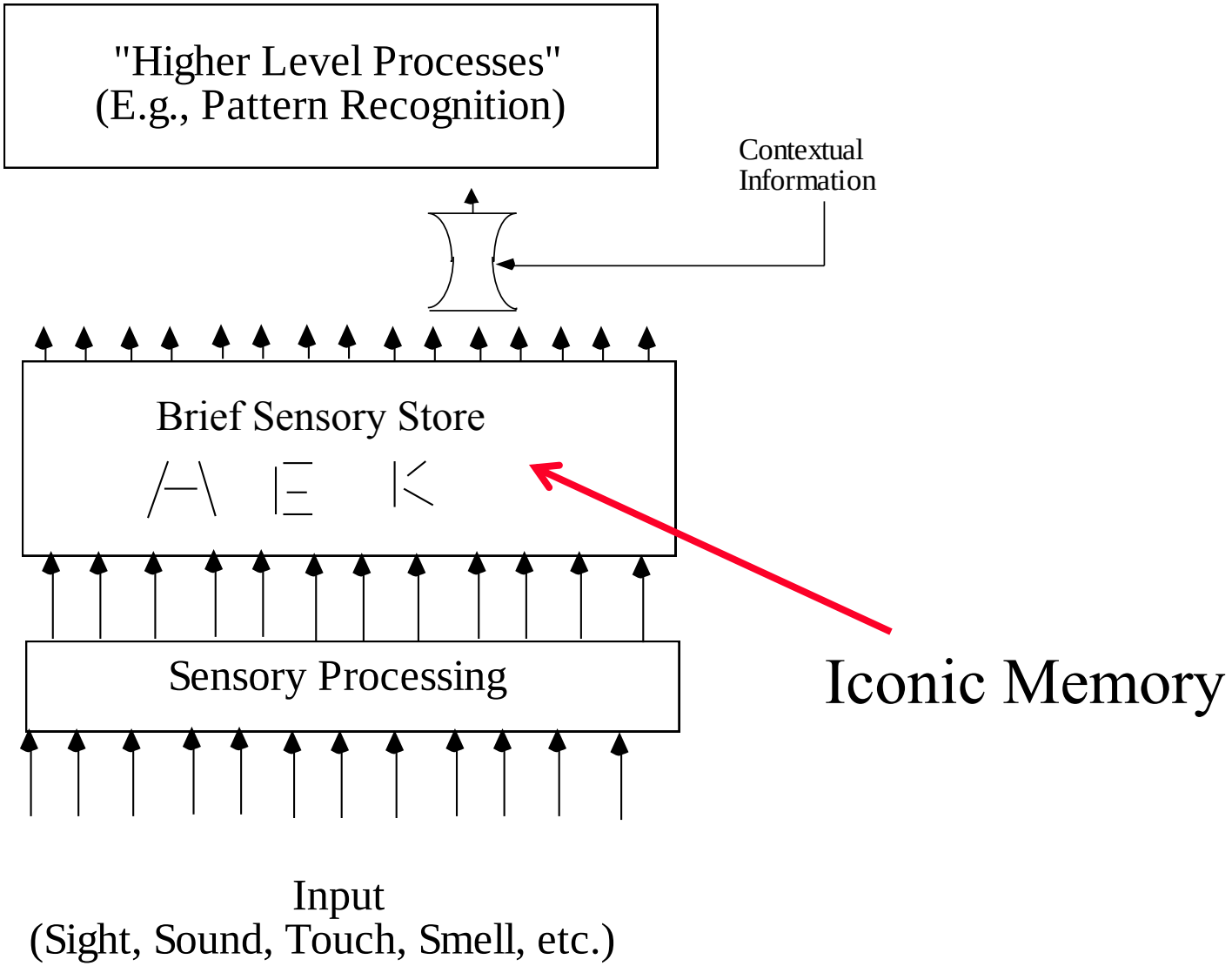
Iconic Memory

Short-term Memory

Long-term Memory

- Declarative Memory (Explicit)
  - Semantic Memories
  - Episodic Memories
- Procedural Memories (Implicit)
  - Motor Procedures
  - Perceptual Procedures

Broadbent Model



Demonstration of Iconic Memory

- You will see a set of letters presented briefly
- Try to retain them all in memory, and afterwards, you will be told which ones to really remember

Remember These Letters….

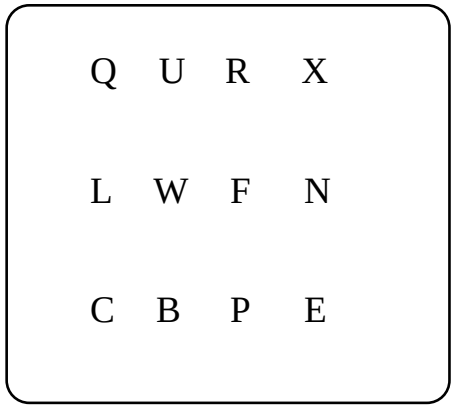
- High tone:

  - Report as many letters as you can remember from the top row

- Low tone:

  - Report as many letters as you can remember from bottom row

Demonstration of Iconic Memory: Sperling (1960)

1. Fixation Point
2. 

(on for 50 msec)
3. Report:
   - Partial:
     - » Receive Cue (top or bottom row)
     - » Report Row
   - Whole: As many as you can.

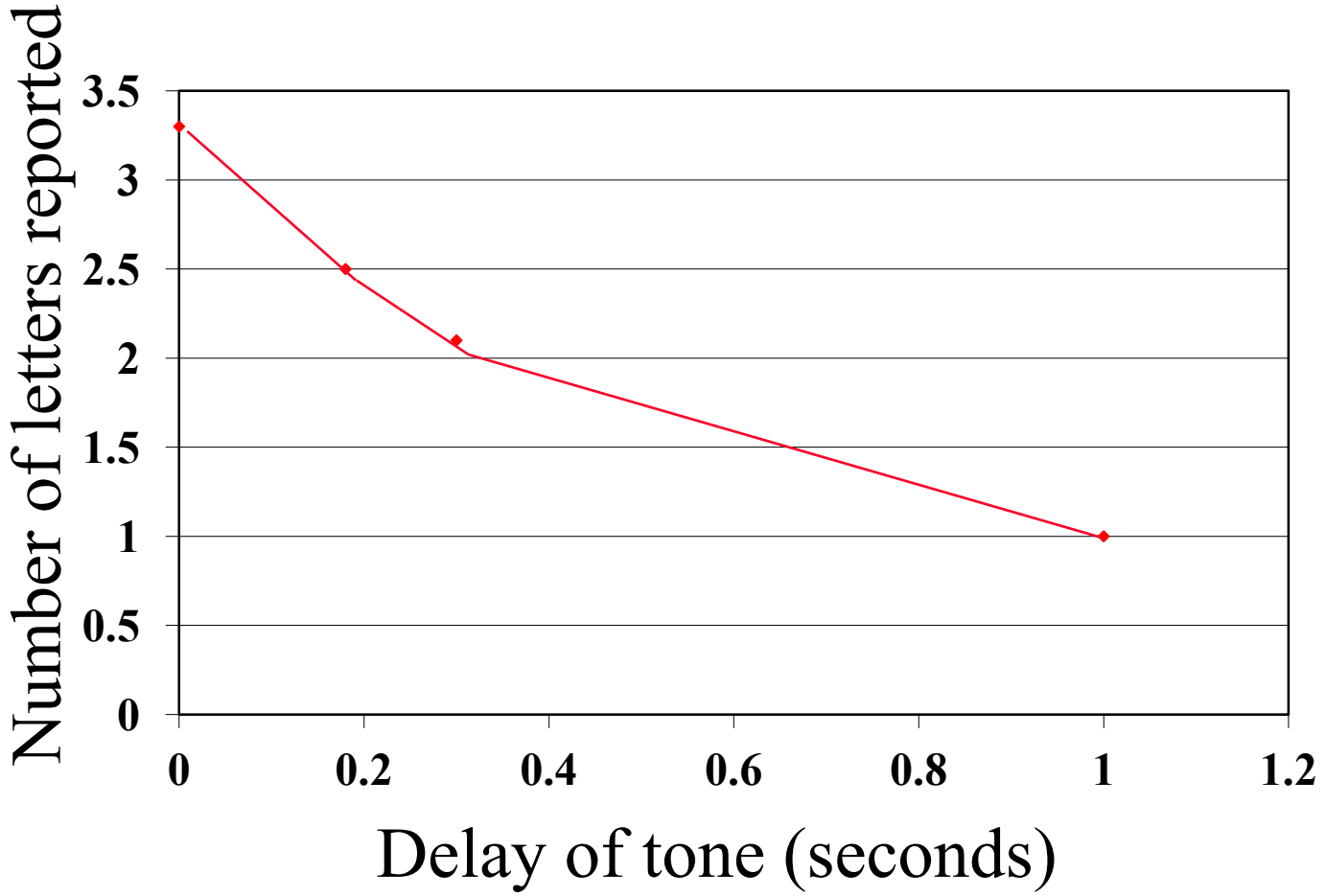
Results: Sperling (1960) Percent of Letters Reported

- Partial Report: 83% correct (3.3 / 4)
- Whole Report: 33% correct (4 / 12)

Sperling (1960)
Time has a big impact on recall...

- Fixation
- Array of Letters (50 msec)
- Delay (0.0 - 1.0 seconds)
- Partial Report Cue (top, middle, bottom)

Number of items recalled as a function of delay time



What can we conclude? Iconic Memory

- Large Capacity
- Fades Rapidly (~ 250 msec)
- Available to higher level processing
- Output Limitations:
  - Need to direct spatial attention to an area to do pattern recognition
    - » Hey, that sounds familiar!

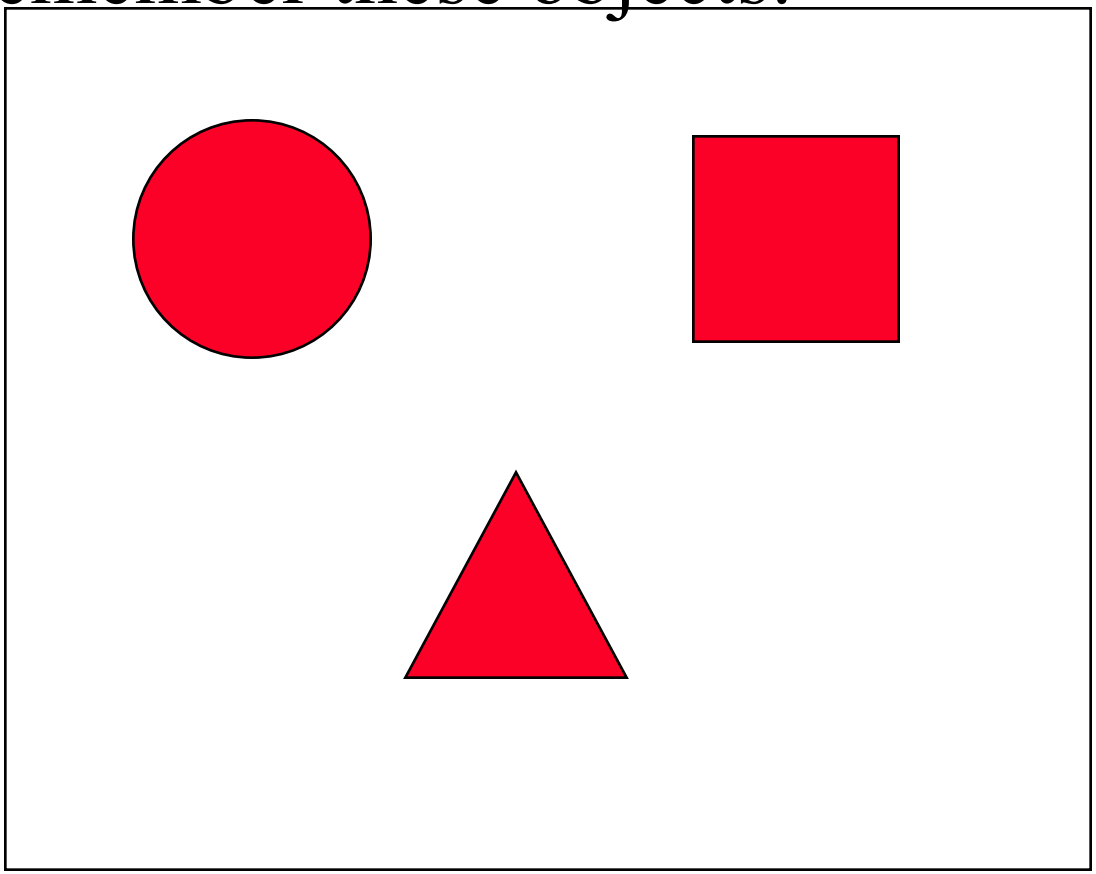
Perceptual and "Verbal" Memories

- Traditionally, two distinct classes of mental representations:
  - Perceptual
  - ~~"Verbal"~~ Symbolic or Abstract

- Symbolic Representations have following properties:
  - Serial Order
  - Hierarchical Structure

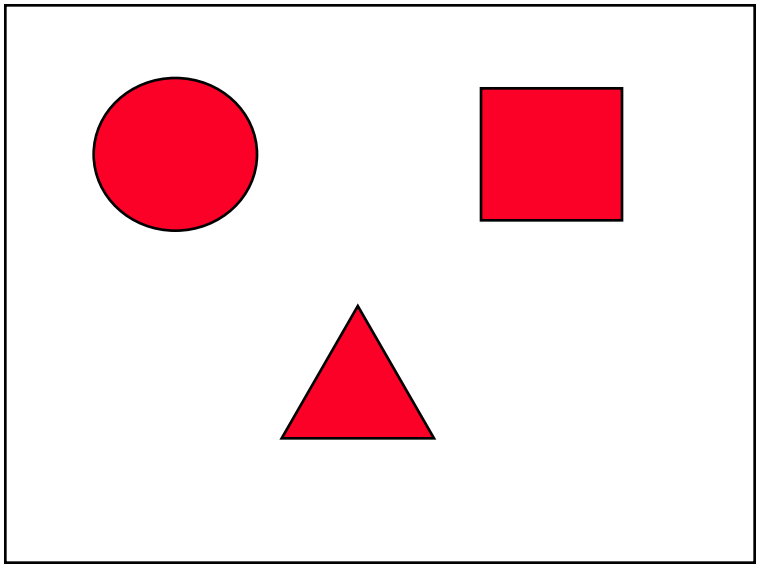
Distinction between Perceptual and Symbolic Info (Santa, 1977)

- Remember these objects:

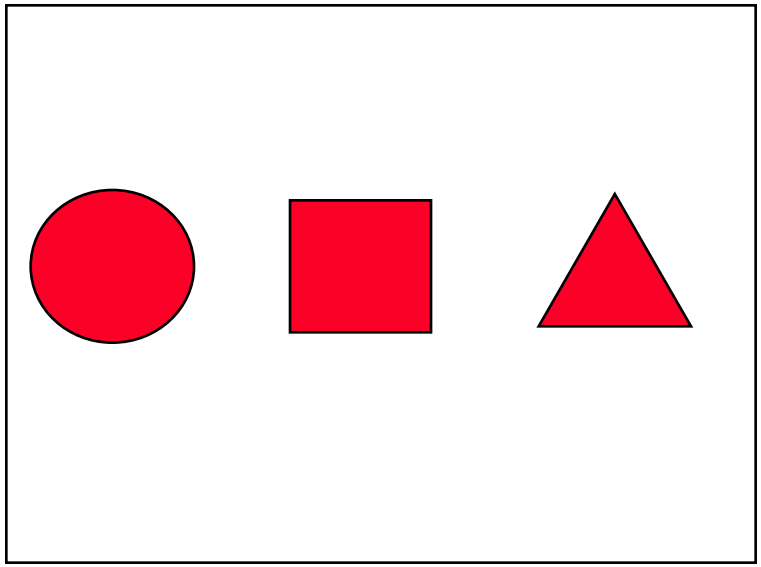


POSITIVE TEST ITEMS

IDENTICAL CONFIG.

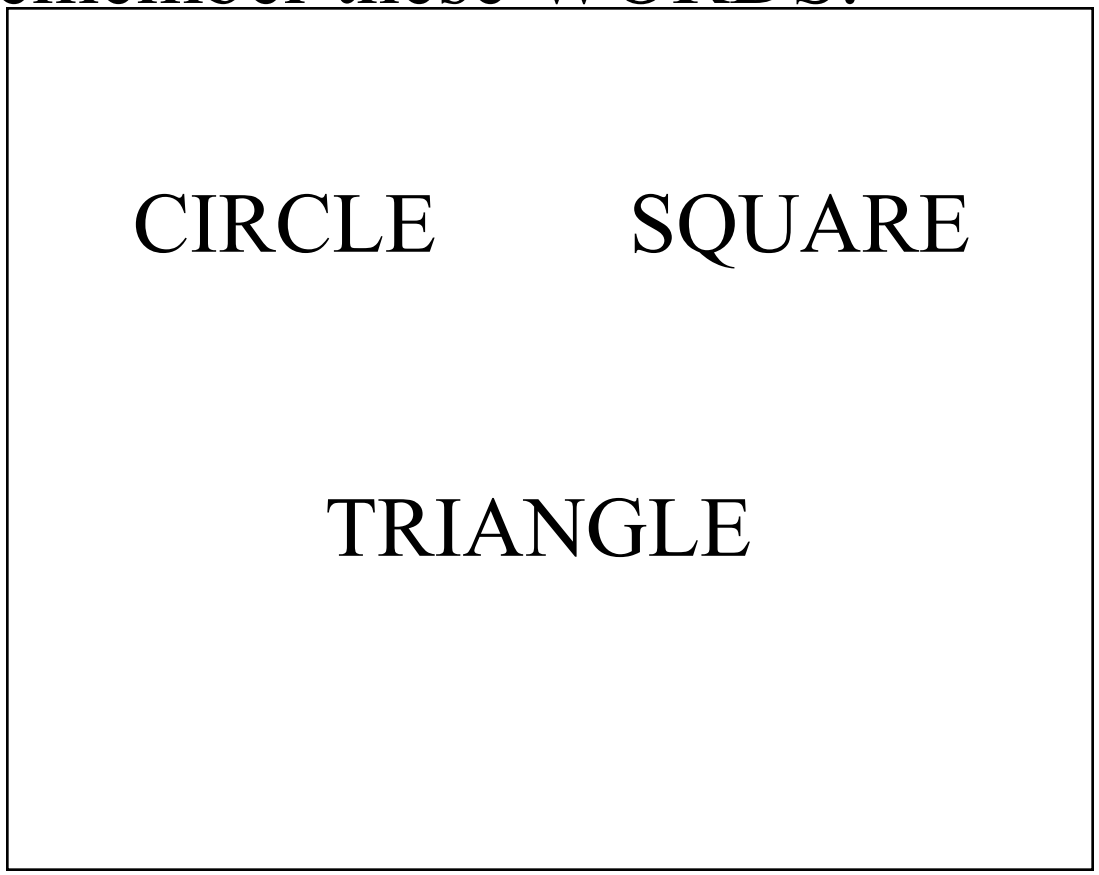


LINEAR CONFIG.



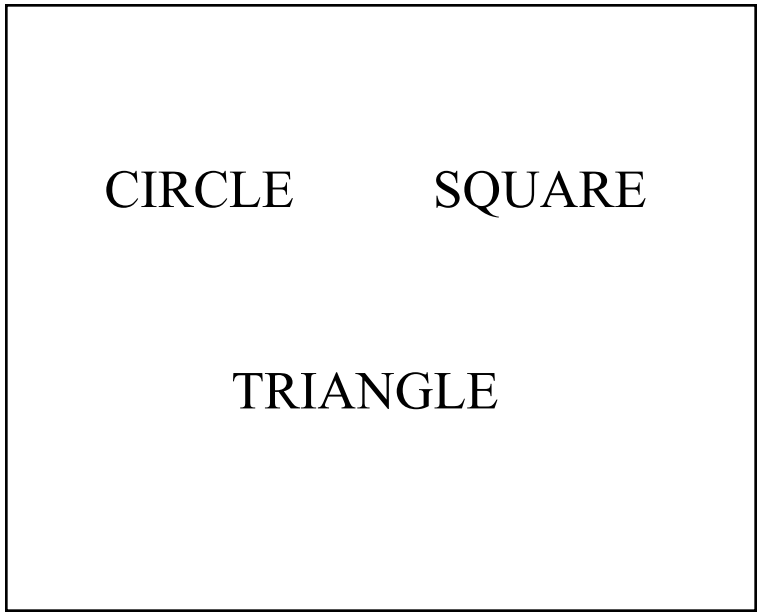
Distinction between Perceptual and Symbolic Info (Santa, 1977)

- Remember these WORDS:

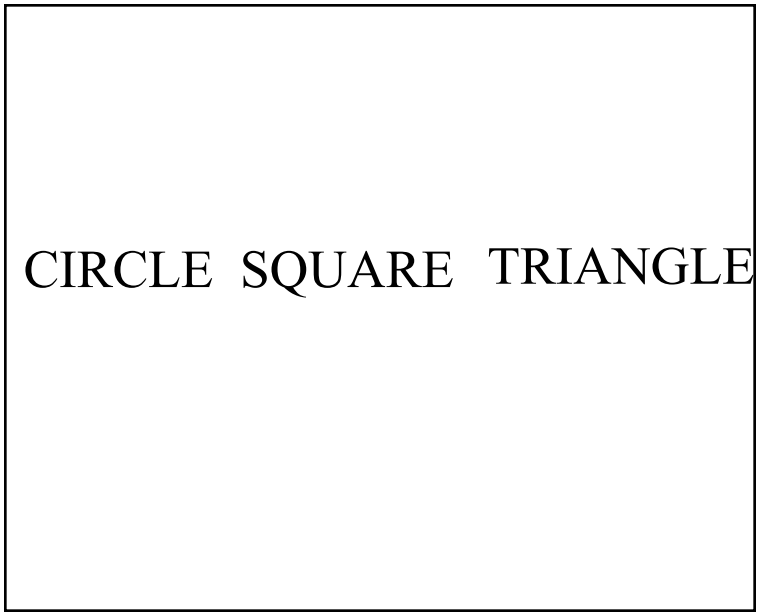


POSITIVE TEST ITEMS

IDENTICAL CONFIG.

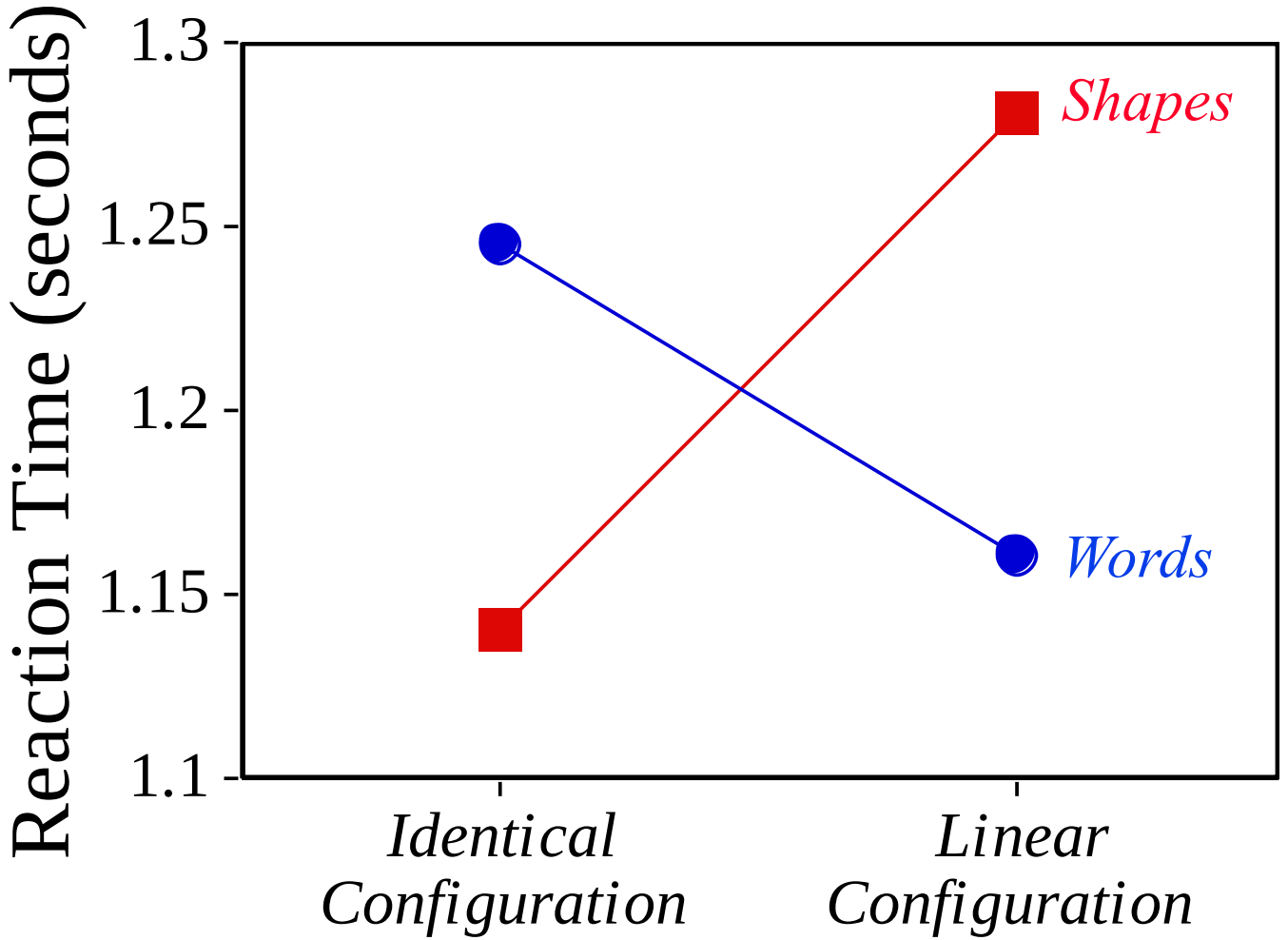


LINEAR CONFIG.



Reaction time to indicate match

(Santa, 1977)



Conclusions

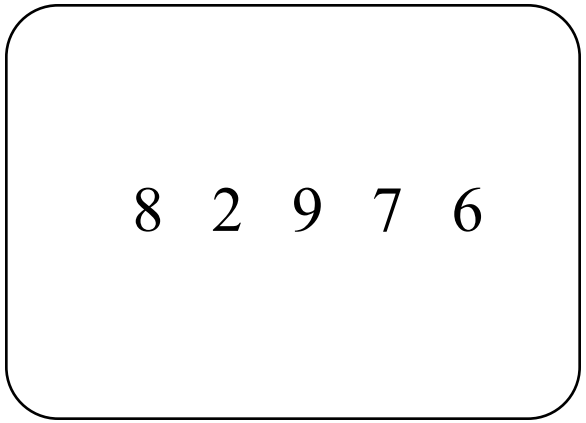
- Linguistic stimuli are encoded as abstract symbols, not images
- Non-linguistic perceptual stimuli are (in part) encoded in perceptual memories, much like mental imagery

What can we determine about symbolic information in memory?

- Sternberg (1969)
  - First to use response times systematically to deduce “cognitive” steps in search tasks

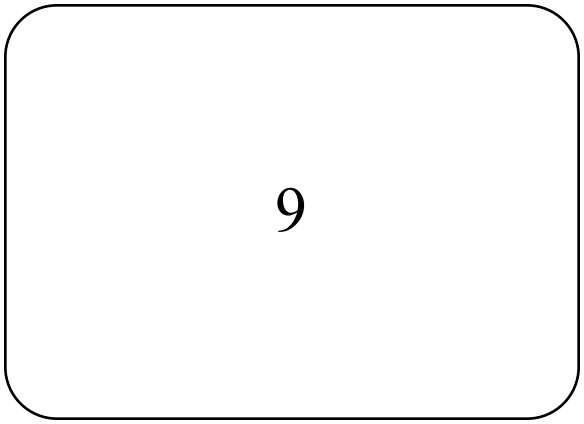
Sternberg (1969)
Recognition from Memory Set

Memory Set:



...Brief Delay...

Test Item:



Serial Self-Terminating Search

8 2 9 7 6

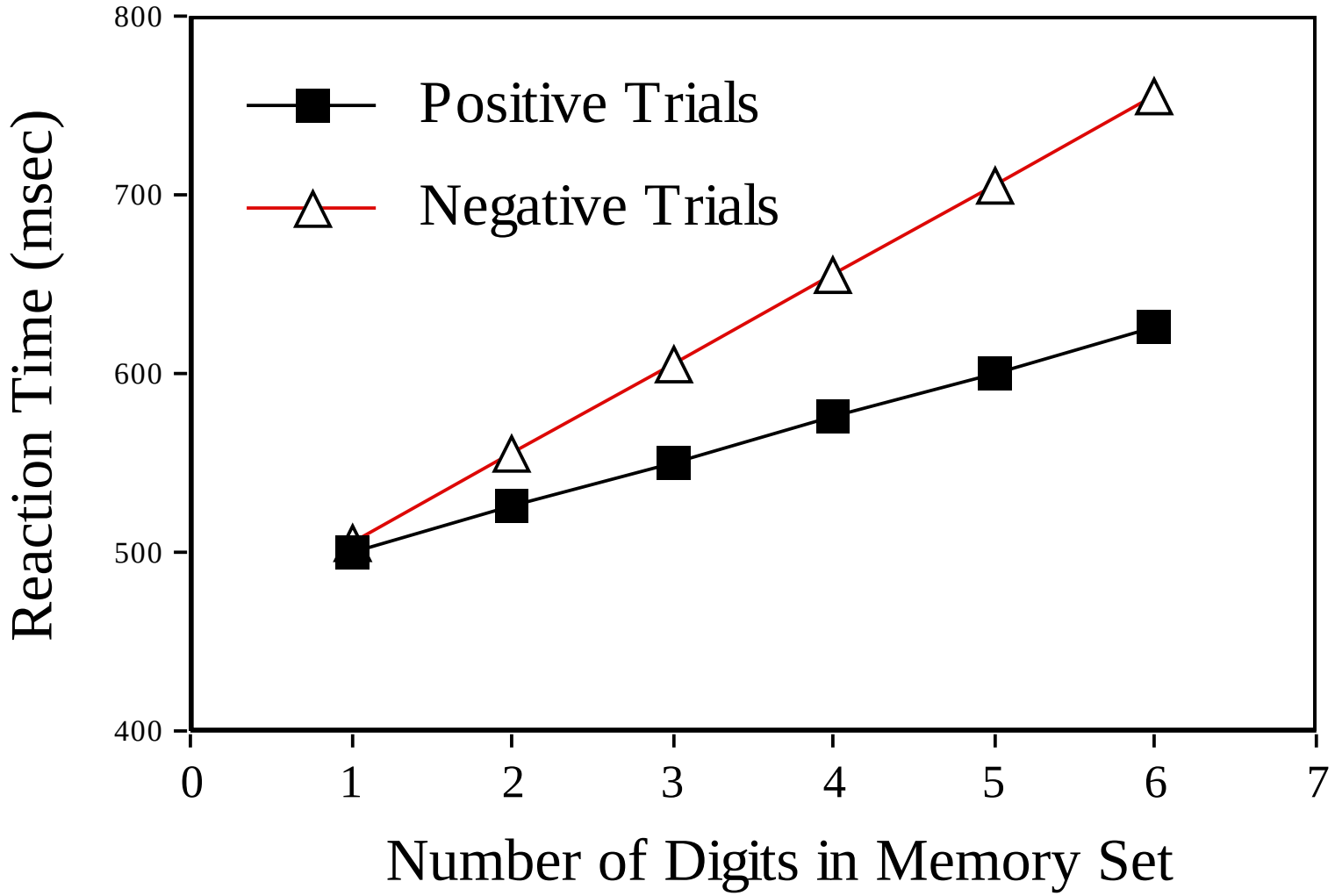
POSITIVE ITEM:

Perceive Stimulus: "9"
Does 9 = 8? NO.
Does 9 = 2? NO.
Does 9 = 9? YES! → RESPOND YES!

NEGATIVE ITEM:

Perceive Stimulus: "3"
Does 3 = 8? NO.
Does 3 = 2? NO.
Does 3 = 9? NO.
Does 3 = 7? NO.
Does 3 = 6? NO. → RESPOND NO.

Predictions for Serial Self-Terminating Search



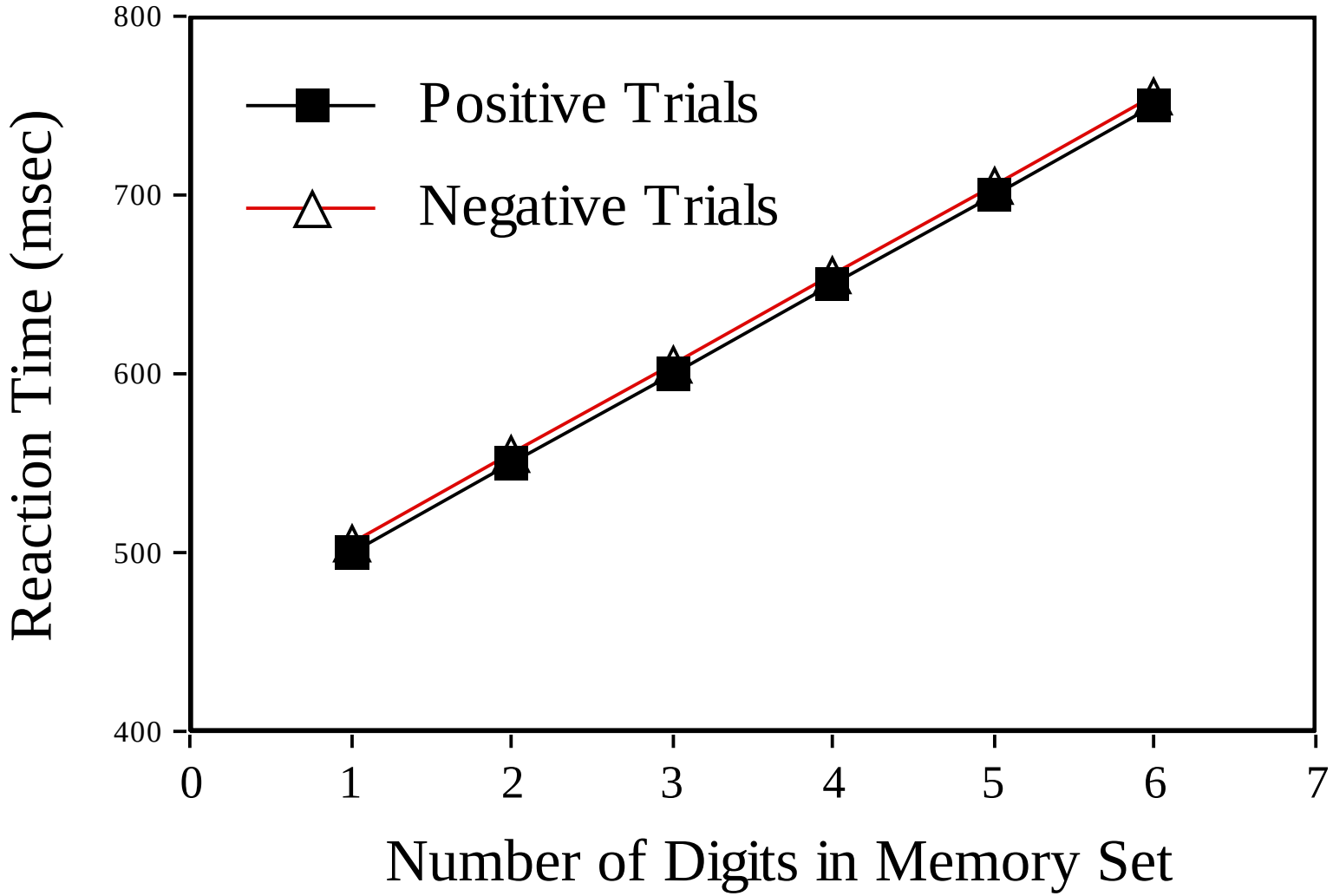
Steps for Serial Exhaustive Search

8 2 9 7 6

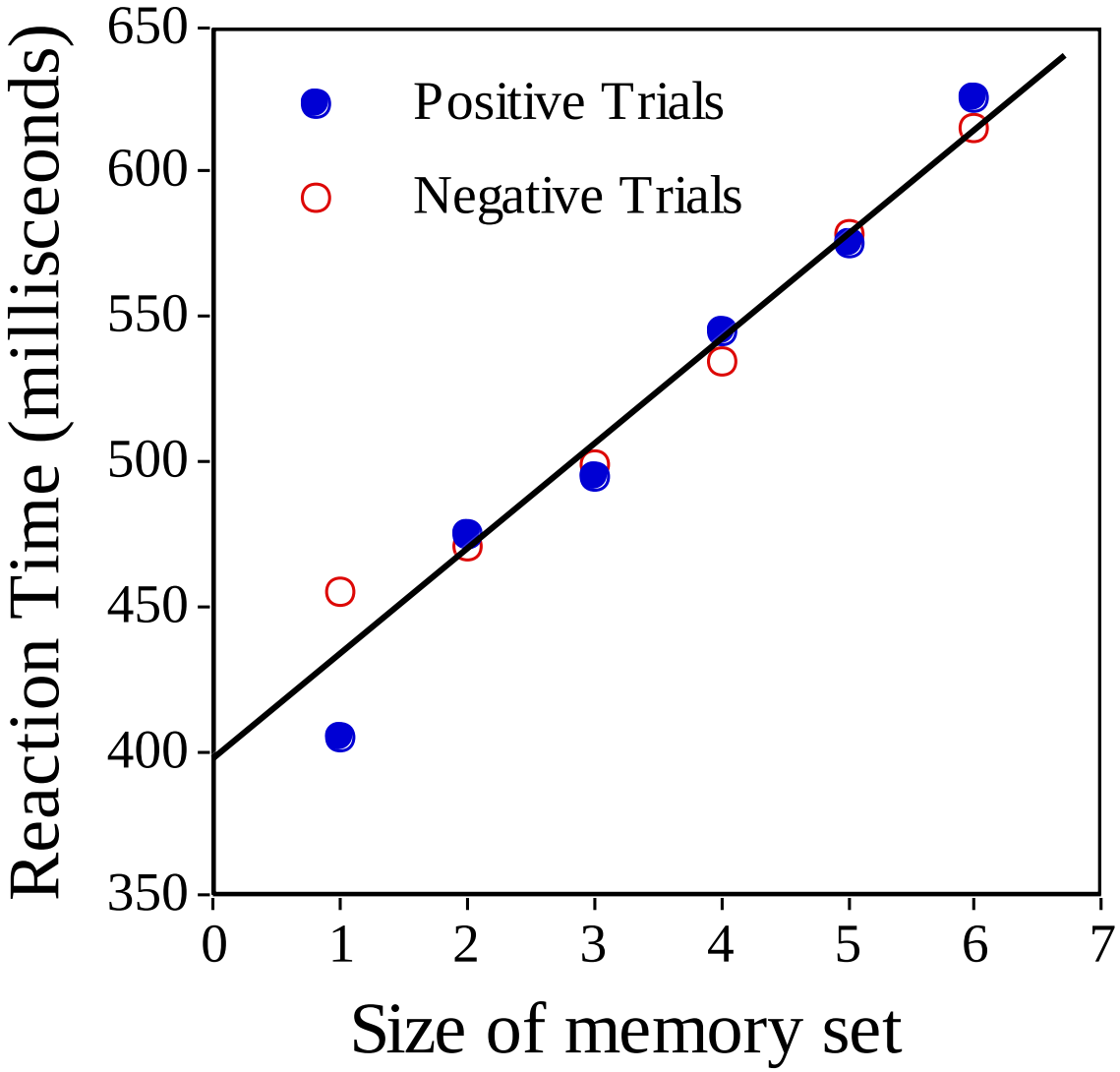
POSITIVE ITEM:

Perceive Stimulus: "9"
Does 9 = 8? NO.
Does 9 = 2? NO.
Does 9 = 9? YES.
Does 9 = 7? NO.
Does 9 = 6? NO. --> RESPOND YES.

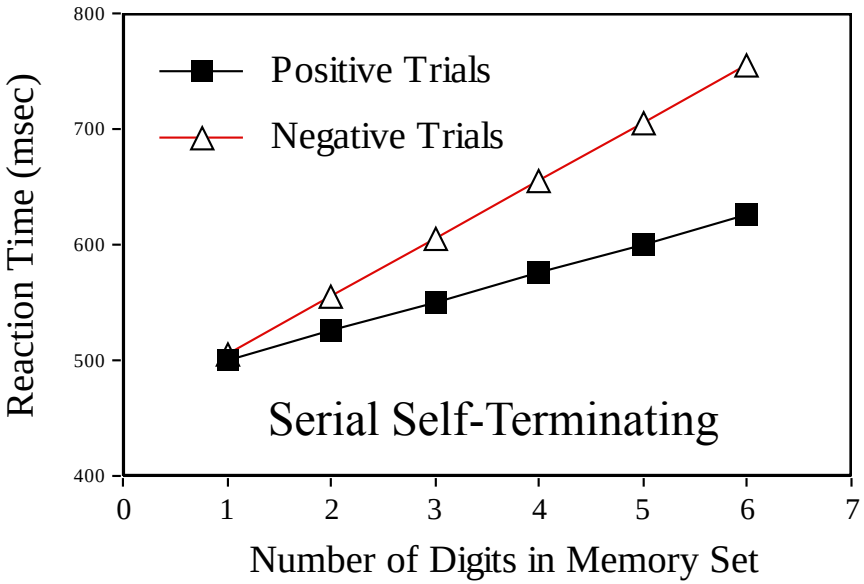
Predictions for Serial Exhaustive Search



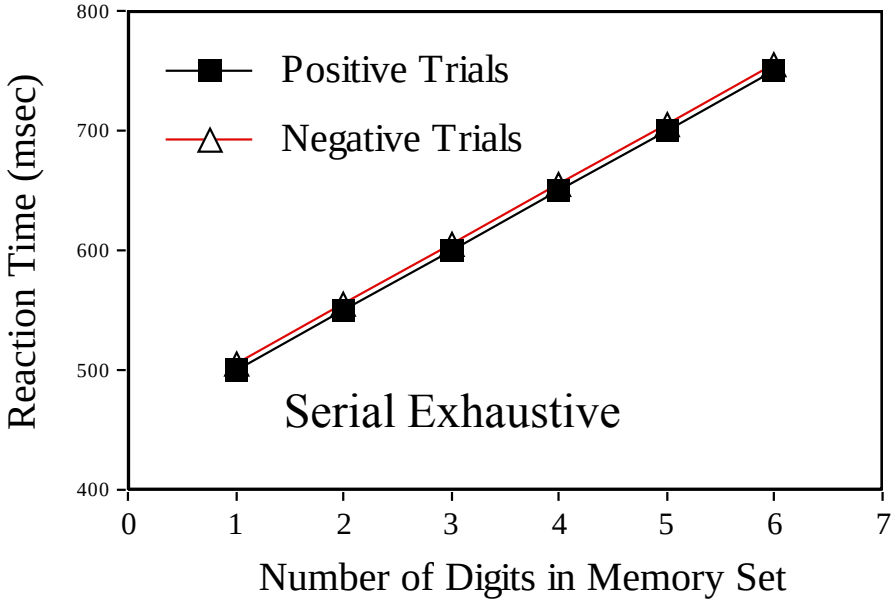
Time needed to respond (Sternberg, 1969)



Searches



(Pattern Recognition)



(Searching a list)

(Basic Visual Feature: Parallel Search)

Why serial exhaustive search?

- “Best match” search requires exhaustive search?
  - But why would we do that here?

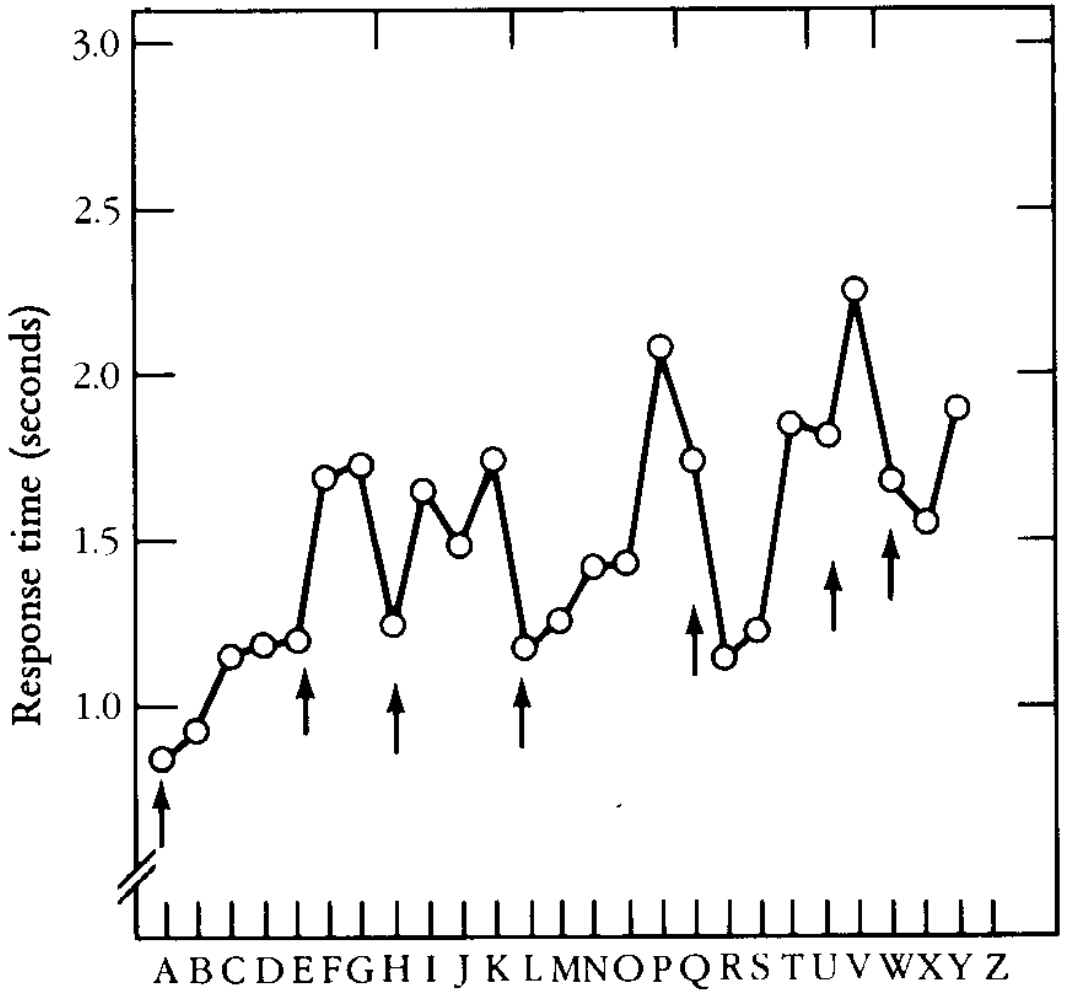
Chunking of Serial Information

- Although lists of linguistic material have serial order, they are likely to contain hierarchical organization
- Chunking =
  - Strategy to group information in hierarchy

Examples of Chunking/Hierarchy

- Language:
  - Information grouped into smaller phrases.
  - “The dog that the man who you met kicked was doing fine.”
- Phrasing in Music
- Alphabet Song (Klahr et al., 1983)

Alphabet Song (Klahr et al., 1983)



Sternberg (1969)

- The alphabet effect on the last slide is an example of "front anchoring"
- In one of Sternberg's original studies, subjects were asked to generate next number from a list of memorized numbers
- Position in list predicted Reaction Time (numbers further in list had longer RTs)

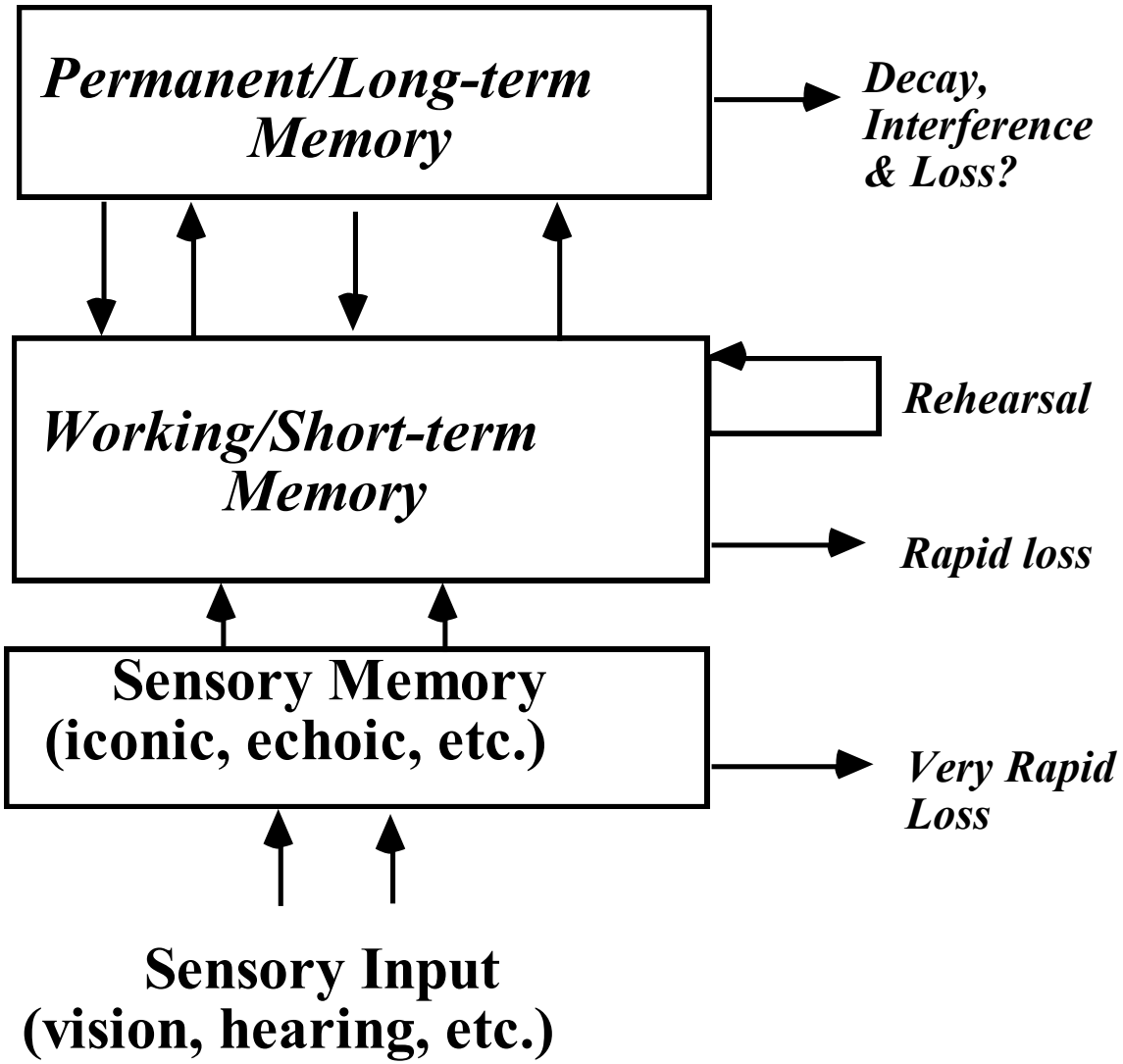
Summary

- Two distinct classes of mental representations:
  - "Imagery" (tied to perception)
  - "Symbolic" (abstract representations)
- Symbolic/Abstract Representations often have the following properties:
  - Serial Order
  - Hierarchical Structure

What we Thought About Symbolic Short-Term Memory Store

- Limited Capacity of Items
  - George Miller, 7±2 items.
- Rehearsal keeps item in the Short-Term Storage Bin (Peterson & Peterson, 1959)
- Rehearsal needed to transfer items into long-term storage (Rundus, 1971)

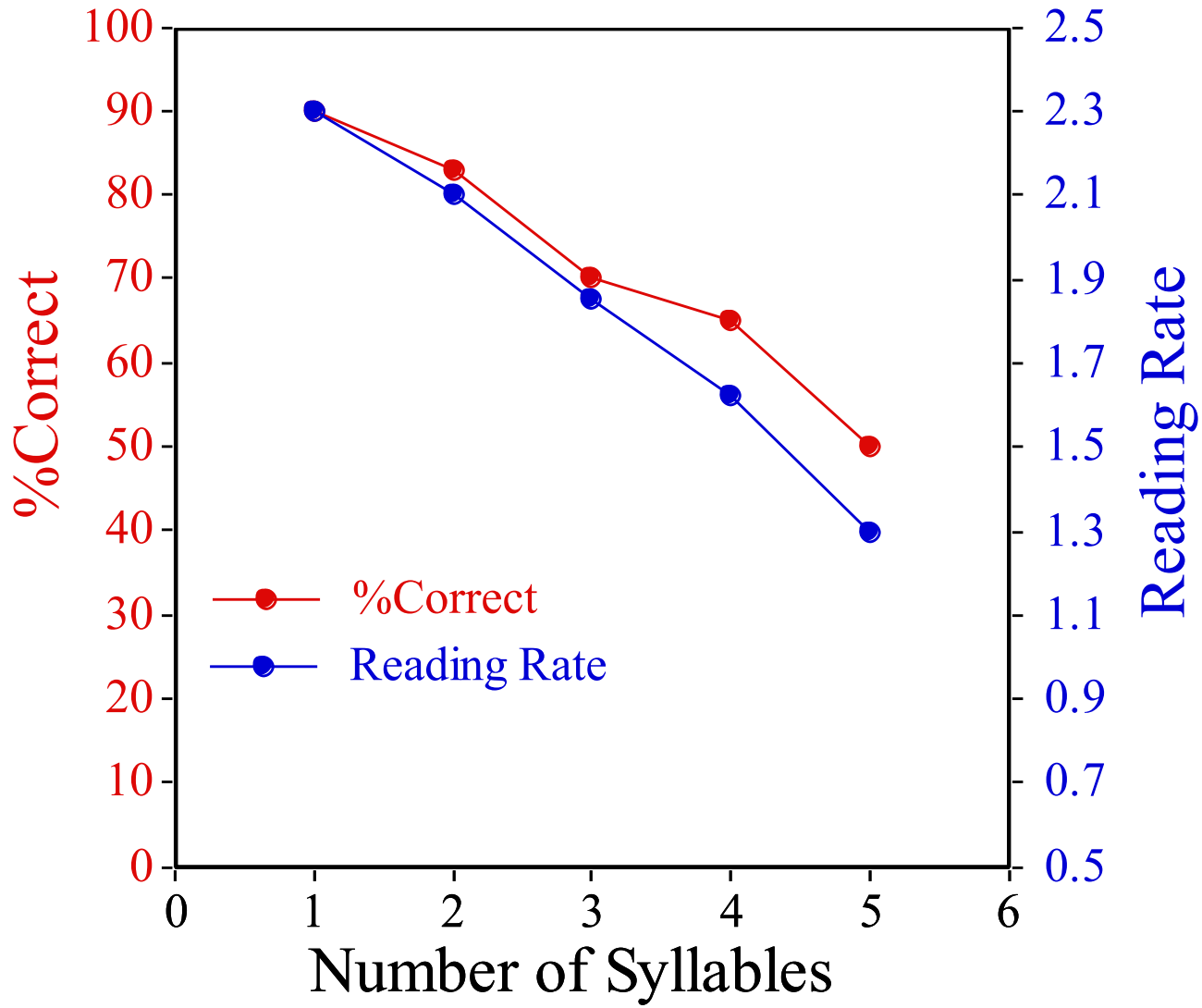
Atkinson & Shiffren Model of Short and Long Term Memory



Vallar & Baddely (1986)

- Different types of Lists:
  - 1 Syllable Words:
    - » “tan, man, sin, hop, wax”
  - 2 Syllable Words:
    - » “market, table, lesser, picket, garden”
- Two different groups of Subjects:
  - Read words aloud a.q.a.p.
  - Recall list of words.

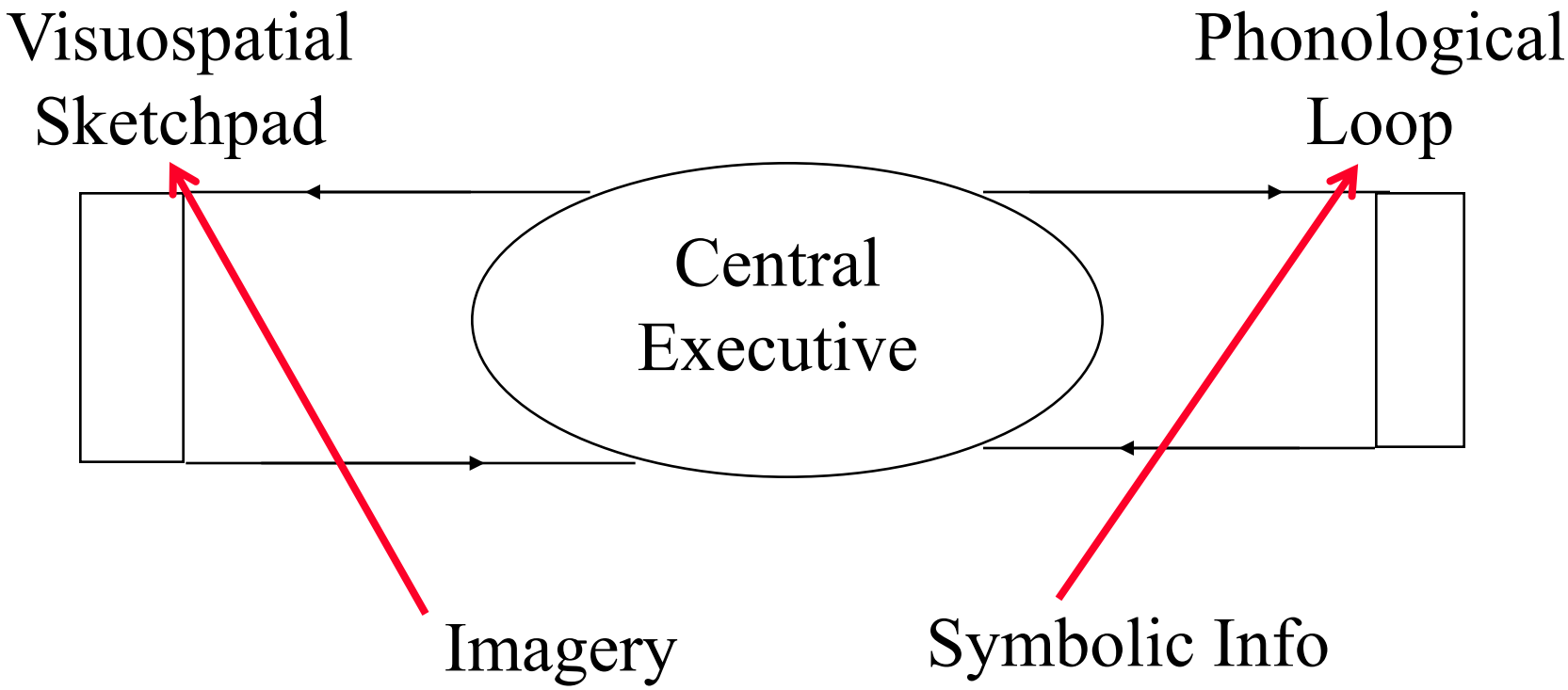
Vallar & Baddely (1986)



Articulatory Loop - The So-Called Storage Bin (Baddely, 1986)

- Memory Span is NOT a fixed number of items
- Speed of Rehearsal determines memory span

Baddely (1986) Slave Systems



Addendum: What kinds of Representations are used in "Phonological Loop"?

- Phonological? (Sounds)
- Articulatory? (Speech Plans)

Representation of Rehearsal (Conrad, 1964)

- Short-Term Memory Test
  - SEE: “K V H J M I”.
  - delay
  - Write down letters.
- Dependent Measure
  - Number/type of Errors
- Result:
  - Confusions tend to be acoustic:
    - » E.g., “V” reported as “B”

Representation of Rehearsal (Conrad, 1964)

- Subjects: Congenitally Deaf
  - Non-Speakers
  - Poor Speakers
  - Good Speakers
- Task: Short-Term Memory Test
  - SEE: “K V H J M I”.
  - delay
  - Write down letters.

Articulatory not Acoustic (Conrad, 1964)

- RESULTS from Cong. Deaf:
  - Non-Speakers
    - » ALL VISUAL ERRORS (“F” -> “P”)
  - Poor Speakers
    - » Mostly Visual Errors (“F” -> “P”)
  - Good Speakers
    - » Mostly Articulatory Errors (“V” -> “B”)

Summary

- Iconic Memory
  - All the input!
  - Very brief (~250 msec)
    - » Even though we don't feel like our representation of the world around us degrades…
- Working Memory
  - Not a storage bin! An active system
  - Two types of representations – visual and "verbal"
  - "Verbal" = articulatory, not just phonological

Take a Break!!

Section 4:
Memory

Transfer to Long-Term Memory

What we Thought About Short-Term Memory Store

- Limited rehearsal time capacity
  - Vallar & Baddely
- Rehearsal keeps memory traces of information active

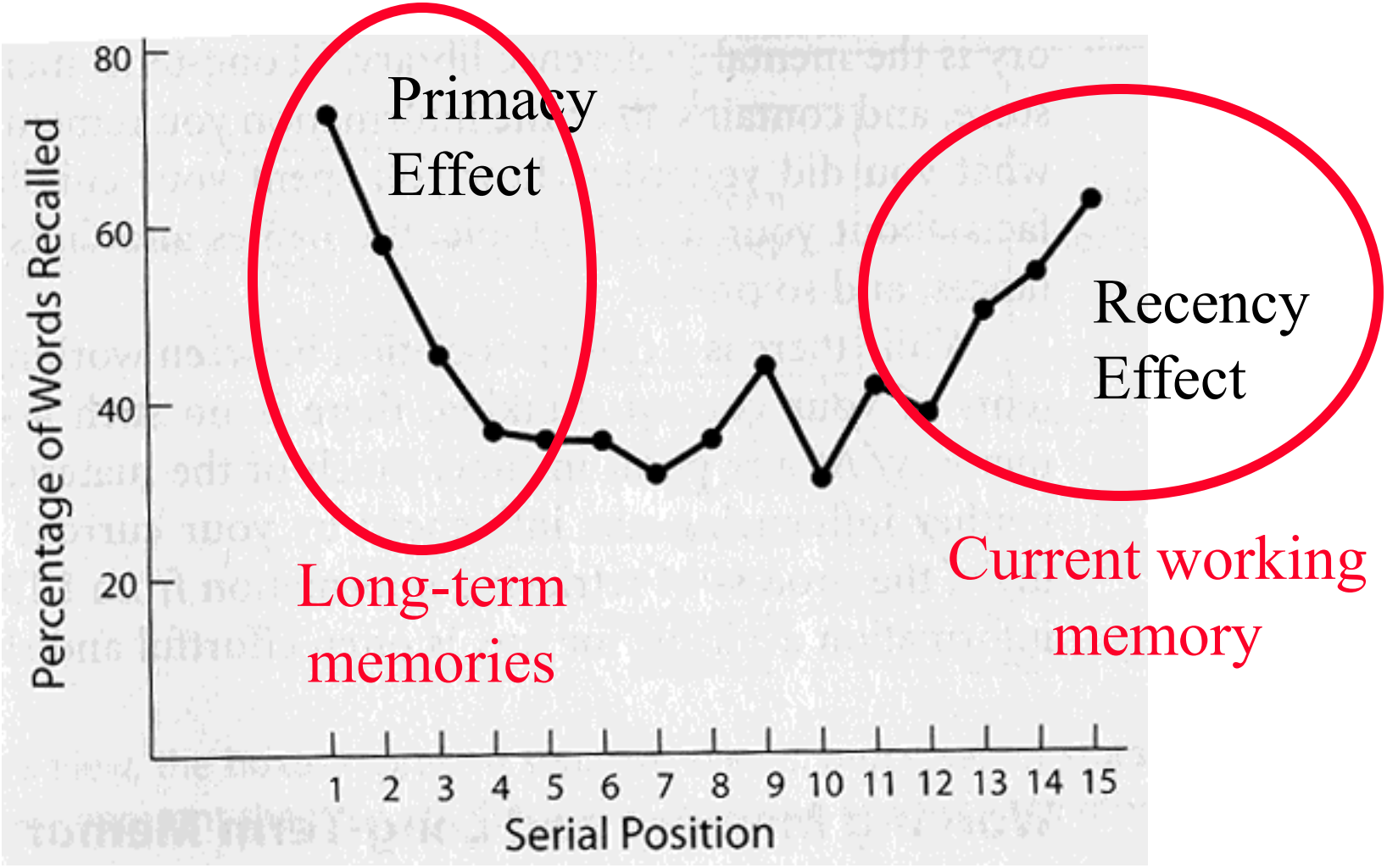
What about ‘transfer’ of memories to long-term storage?

- How do newly perceived events, which are being stored in working memory, make their way to longer-term systems?

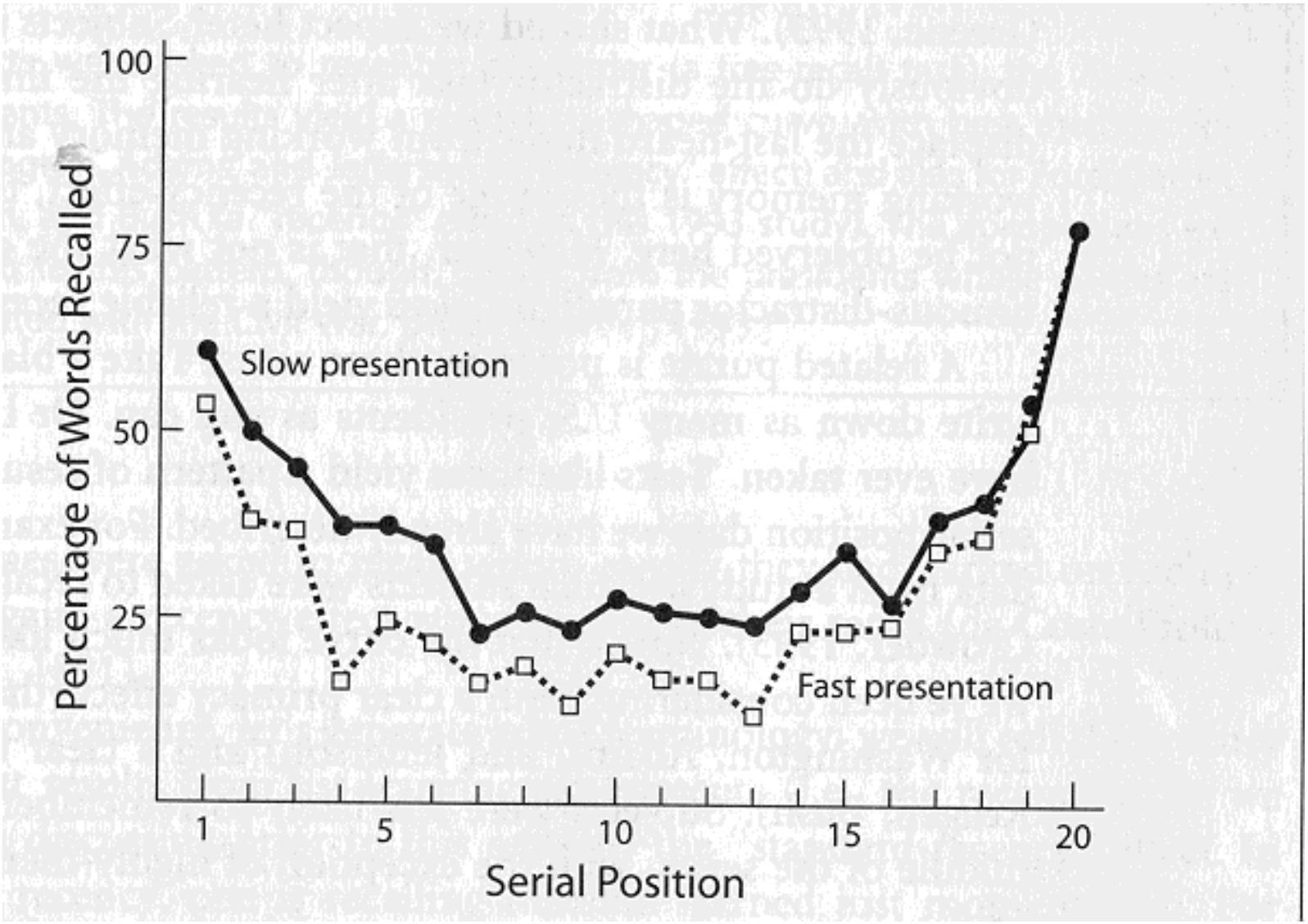
Transfer to long-term memory:

- Demonstration:
  - I will read aloud a list of 15 words.
  - At the end of the list, I will say “recall”.
  - At that point, you should write down as quickly as possible all the words you can remember, in any order.

Serial Position Curve
e.g., Murdock, 1962



Primacy Effect due to Transfer to Long-Term Memory



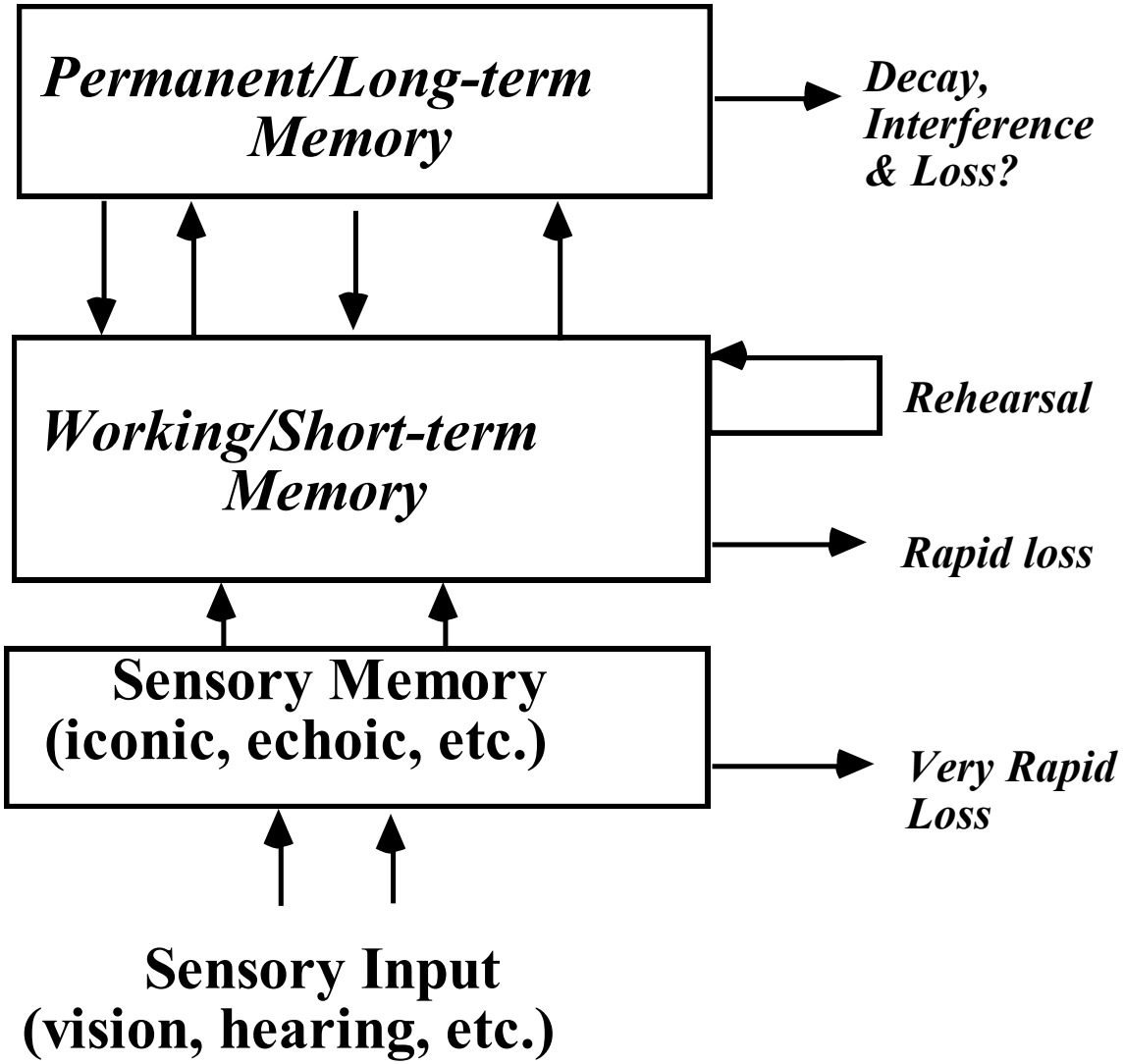
What we Thought About Short-Term Memory Store

- Limited rehearsal time capacity
  - Vallar & Baddely
- Rehearsal keeps memory traces of information active
- **Rehearsal needed to transfer items into long-term storage (Rundus, 1971)?**

Transfer to Long Term Memory

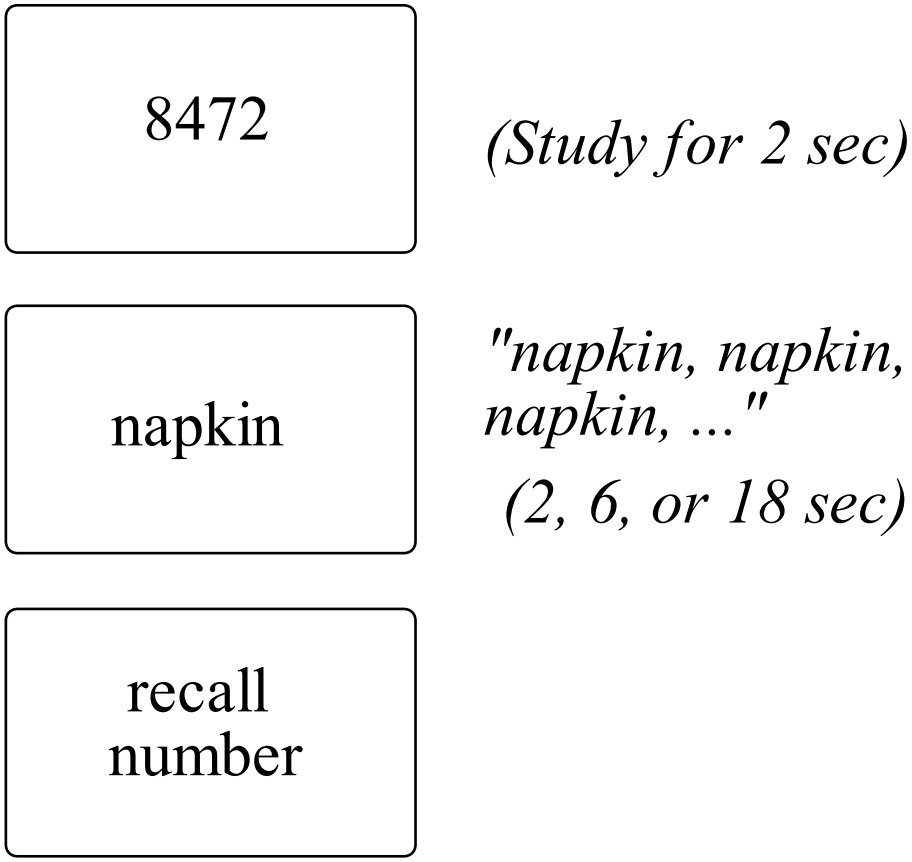
- Demonstration:
  - I will read aloud a list of 10 word pairs.
  - Repeat the word pairs to yourself again and again until the next pair comes
  - I will then present you with the 1st word from each pair, and you will try to recall the corresponding 2nd word

Atkinson & Shiffren Model of Short and Long Term Memory



Does Rehearsal induce transfer to long-term storage?

- Glenberg, Smith & Green (1977)



Glenberg, Smith & Green (1977)

- Surprise! Please recall the words!

Percent Correct
Words that were rehearsed for:

2 seconds	6 seconds	18 seconds
11%	7%	13%

Transfer to Long Term Memory

- Demonstration:
  - I will read aloud a list of 10 word pairs.
  - Imagine the two objects in the word pair interacting with each other in some way.
  - I will then present you with the 1st word from each pair, and you will try to recall the corresponding 2nd word

Transfer to Long-Term Memory

- What is the secret to a long life?
  - Friends.
- What determines the long life of a memory?
  - Friends. Links to other memories.

Depth of Processing (Craik & Lockhart, 1974)

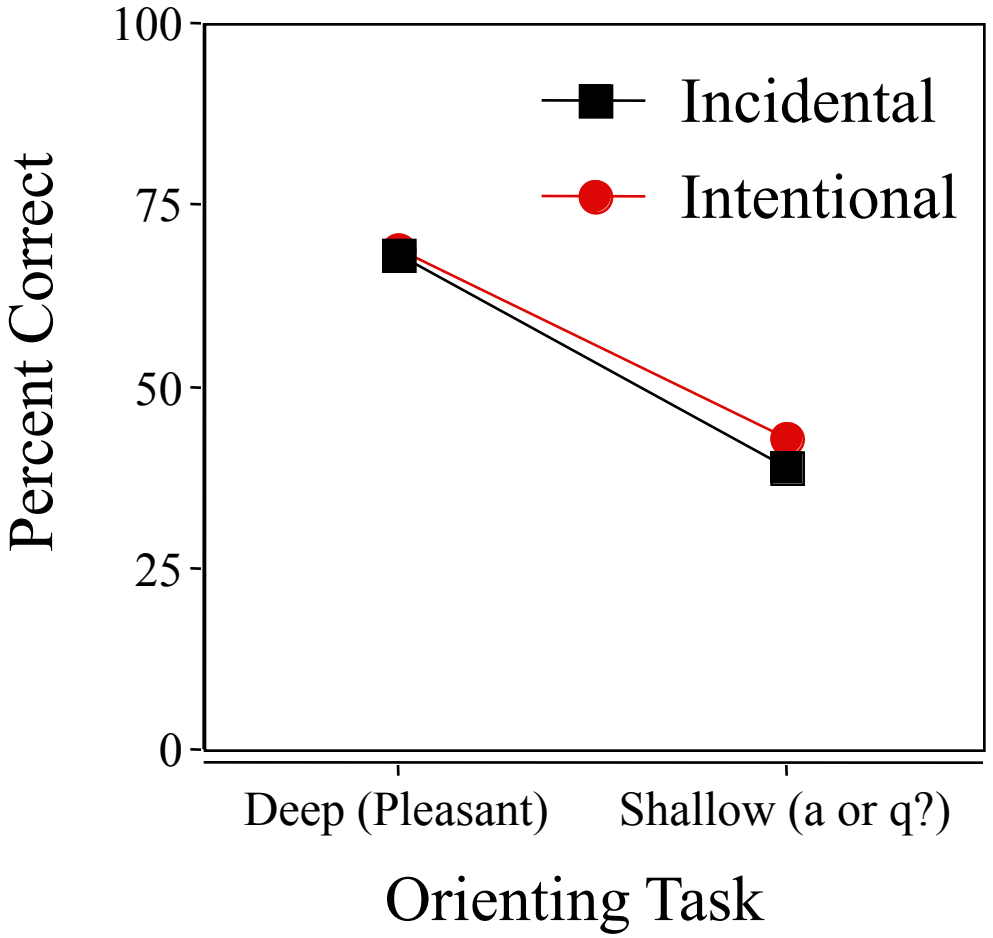
- Prior research overemphasized the importance of articulatory rehearsal.
- BUT….Different Kinds of Rehearsal

"Maintenance Rehearsal" ⟷ "Elaborative Rehearsal"

Evidence for depth of processing: Hyde & Jenkins (1973)

- See a sequence of Words
- 2x2 Design:
  - Factor 1: Orienting
    - » Shallow: Monitor for A or Q in each word
    - » Deep: Rate pleasantness of each word
  - Factor 2: Type of Learning:
    - » Incidental (surprise quiz at end)
    - » Intentional (told in advance about quiz)

Hyde & Jenkins (1973)



Rating pleasantness of word nearly doubled the ability to recall it!

Warning people about test had no effect!

Further Evidence: Craik and Tulving (1975)

- **Three types of orienting tasks:**
  1. Physical structure

     Is the word in upper case or not?
  2. Phonological structure

     Does the word rhyme with _____?
  3. Semantic structure

     Does it fit in the sentence:

     "She cooked the _____?")

RESULT: NUMBER 3 IS BEST.

Craik and Tulving (1975)

Same method as before, except now all orienting tasks are semantic.

Simple: *"She cooked the _____."*

Medium: *"The _____ frightened the children."*

Complex: *"The great bird swooped down and carried off the struggling _____."*

Result: Better recall as sentences become more complex

Problem with Depth of Processing

- So what determines depth?
  - Complexity?
  - Semantics?

Kolers (1979)

- Recall of Sentences.

Upside down sentences are remembered better.

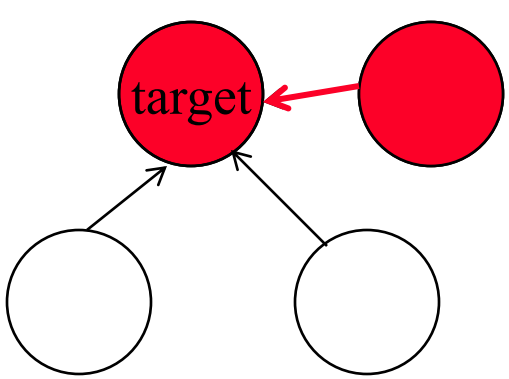
- Amount of encoding time determines memory strength??
  - Probably not.

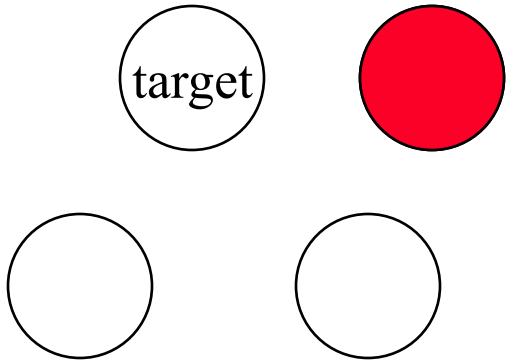
Elaborateness of Processing

- Degree of Interconnectivity determines strength of memory traces.
- Craik & Tulving Results:
  - Connection to other knowledge.
- Koler's Results:
  - Connection to EPISODIC Memories.

Why would connections to other memories help?

- Spreading activation!
- A memory that is linked to other memories means that the memory has more potential retrieval cues (things that could remind you of the target memory).





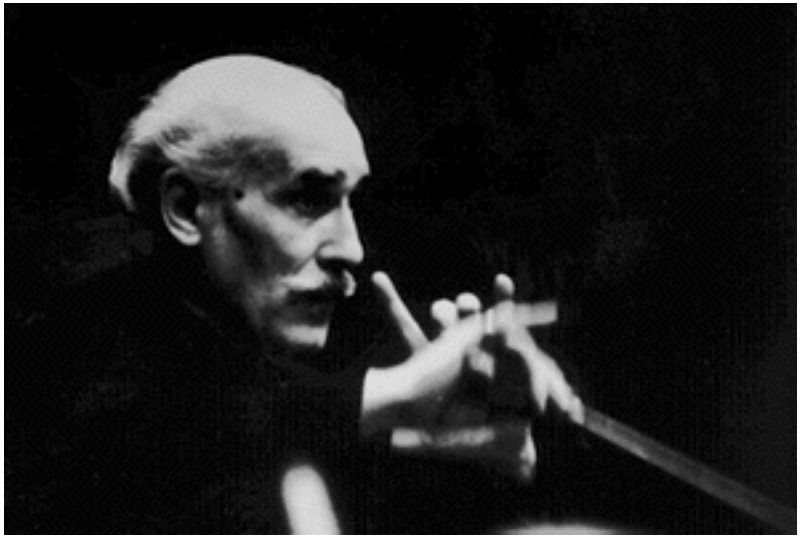
What if there are no links? Mnemonic Devices (Bower, 1973)

- Trick memory system into making random sequences appear meaningful.
- E.g., remembering names and numbers by associating it to other long-term knowledge.
  - Professor Nappa's favorite character on Parks and Recreation is Ron Swanson, so I'll imagine a *swan* hanging out with her *son*…

Summary: What determines the strength of a memory trace?

- Rehearsal Alone? NO
- Intention to Remember? NO (??)
- Elaborateness/Depth of Processing? YES
  - Strong memory traces have lots of friends.

Famous Feats in Memory



Conductor Arturo Toscanini

- Memorized every note of every instrumental part for 250 symphonic works and 100 operas.

Chunking and Expertise: *The game of Chess*

- Do Grand Masters have bigger memories?

- *What are memory representations of Grand Masters?*

Memory for Chess Positions (de Groot, 1965)

	Number of Pieces Recalled	
	Experts	Novices
Middle of Game	**20**	5
Random	5	5

Eye-Movements in Chess Task (Chase & Simon, 1973)

- Two Chess Boards.
  - One with pieces on it.
  - One with no pieces on it.
- Task: Reproduce pieces on blank board.

- AFTER EACH GLANCE:
  - Experts put out 4-5 pieces.
    - » "Tactical groupings"

Subject S.F. (Ericsson, Chase, & Faloon)

- Work Study Student
- Sophomore
- Average Grades

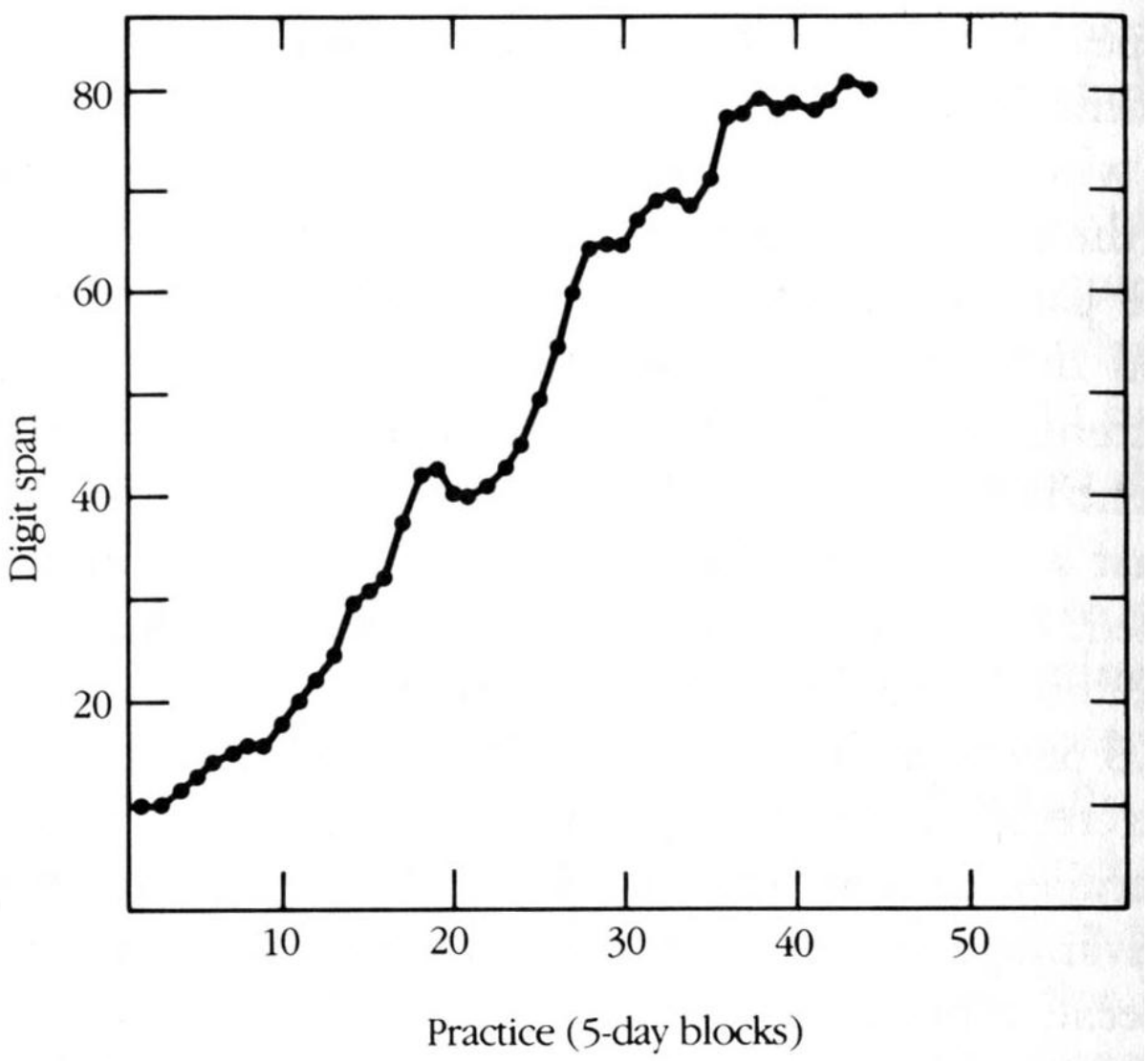
- *Memory Span Task*
  - 1 hour/day
  - 3 to 5 days/week
  - For 1.5 years

S.F.'s Memory Span Task

- Hear list of random digits (1 per second).
- Recall the sequence.
- If sequence correct,
  - next sequence increased by one.
- If sequence incorrect,
  - next sequence decreased by one.

(On 50% of trials--describe how you did it.)

Subject S.F. Memory Span



How did S.F. do it??

- Mnemonic Associations
- Retrieval Structures

Intuitions Reported by S.F.: Mnemonic Associations

- 3 4 9 2 = "3 minutes and 49 point 2 seconds, near world-record mile time"
- 8 9 3 = "89 point 3, a very old man"

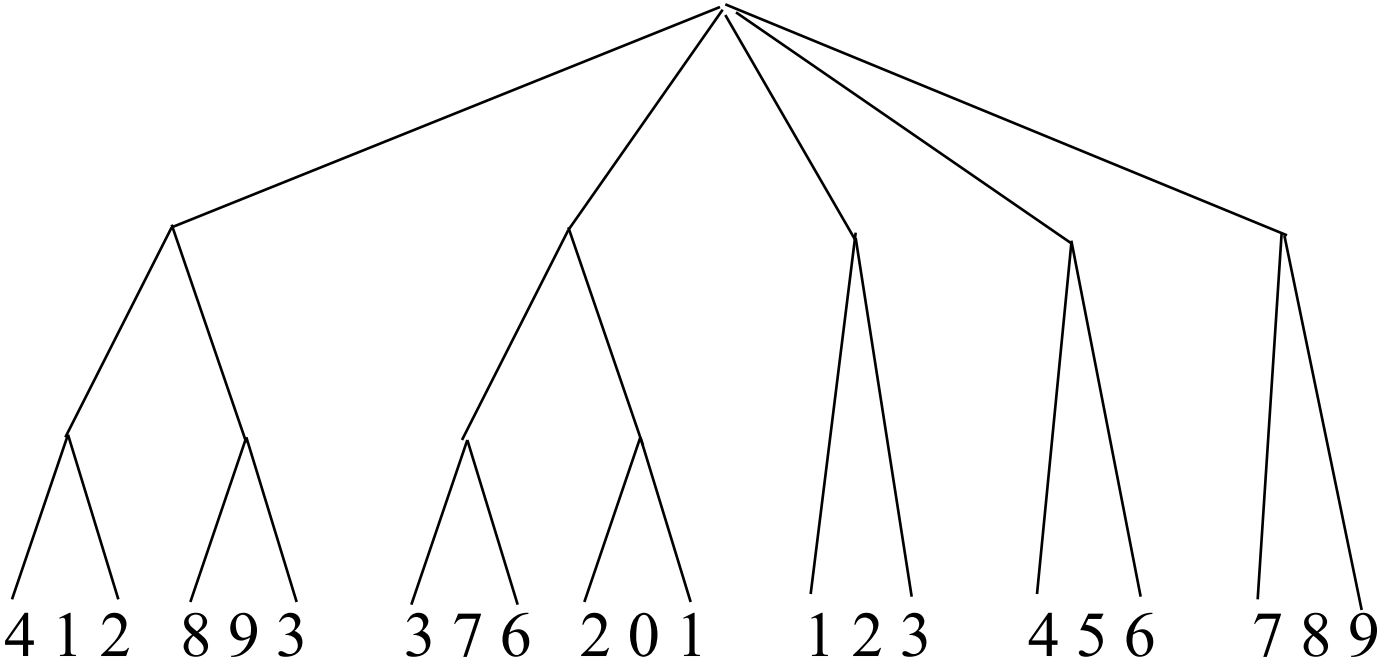
Experimental Evidence for Mnemonic Associations

- What about lists of letters?
  - S.F.'s Performance: About 7 letters

Intuitions Reported by S.F.: Retrieval Structures

- Chunking:
  - Form sub-groups of numbers
  - Form associations between sub-groups
  - *[(4-digit time/4-digit time), (4-digit time/4-digit time), (4-digit time/4-digit time)] - [(4-digit time/4-digit time), (4-digit time/4-digit time), (4-digit time/4-digit time)] - [(4-digit time/4-digit time), (4-digit time/4-digit time), (4-digit time/4-digit time)] < rehearsal buffer>*

S.F.’s Final Retrieval Structure



Experimental Evidence for Retrieval Structure

- Production prosody
- After reading list: presented with 4 digits:
  - Recall group of numbers before or after:
    - »*Cross super-group: 10 sec.*
    - »*Cross sub-group: 4.4 sec.*

Experts Develop a Language.
Example: Memorize the following:

EHT CTA DHASEC HTE GDO.

THE CAT CHASED THE DOG.

Experts

- Experts have memorized hundreds of thousands of sub-patterns

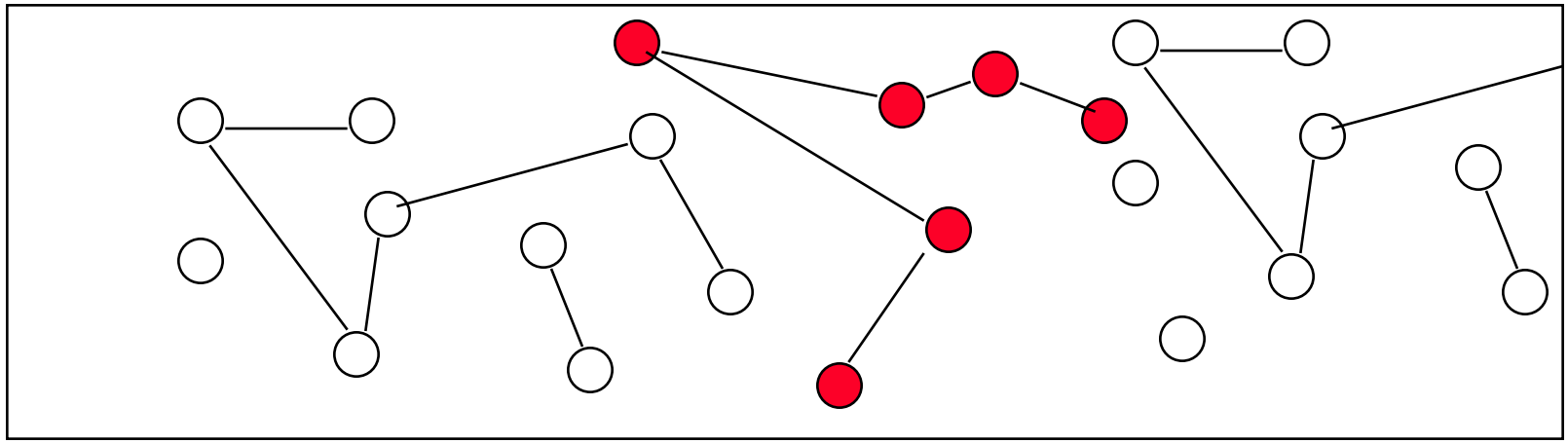
- Chess Pieces = Letters
- Tactical Groupings = Words
- Whole Board = Sentence

Summary of Expertise

- Chunks are created, and then associations are built between chunks (this is getting into long-term memory territory)

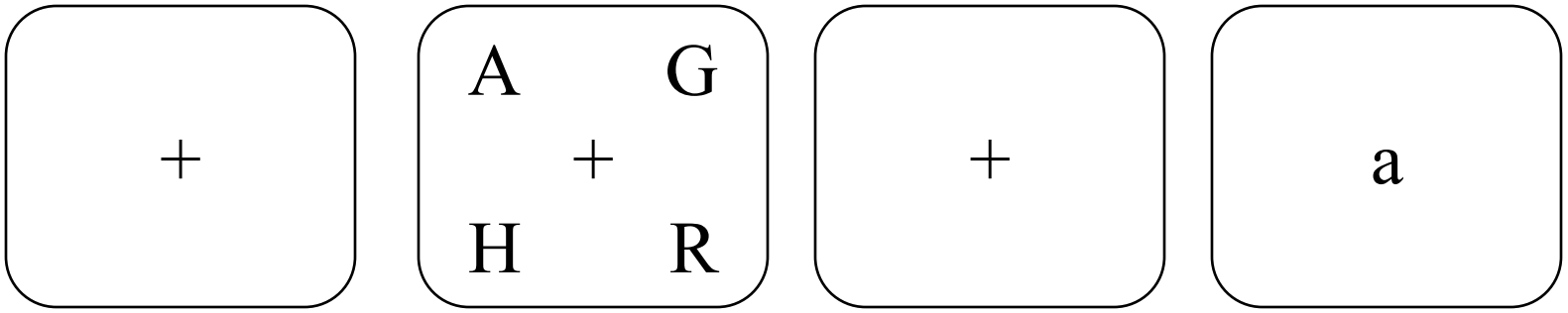
New View of Working & Long-Term Memory

- Working Memory is not a place, but a system for maintaining currently active memory traces.
- Memory traces can be strengthened, not by rehearsal alone.



Bonus! Where is this Anyway? Neural Basis of Working Memory

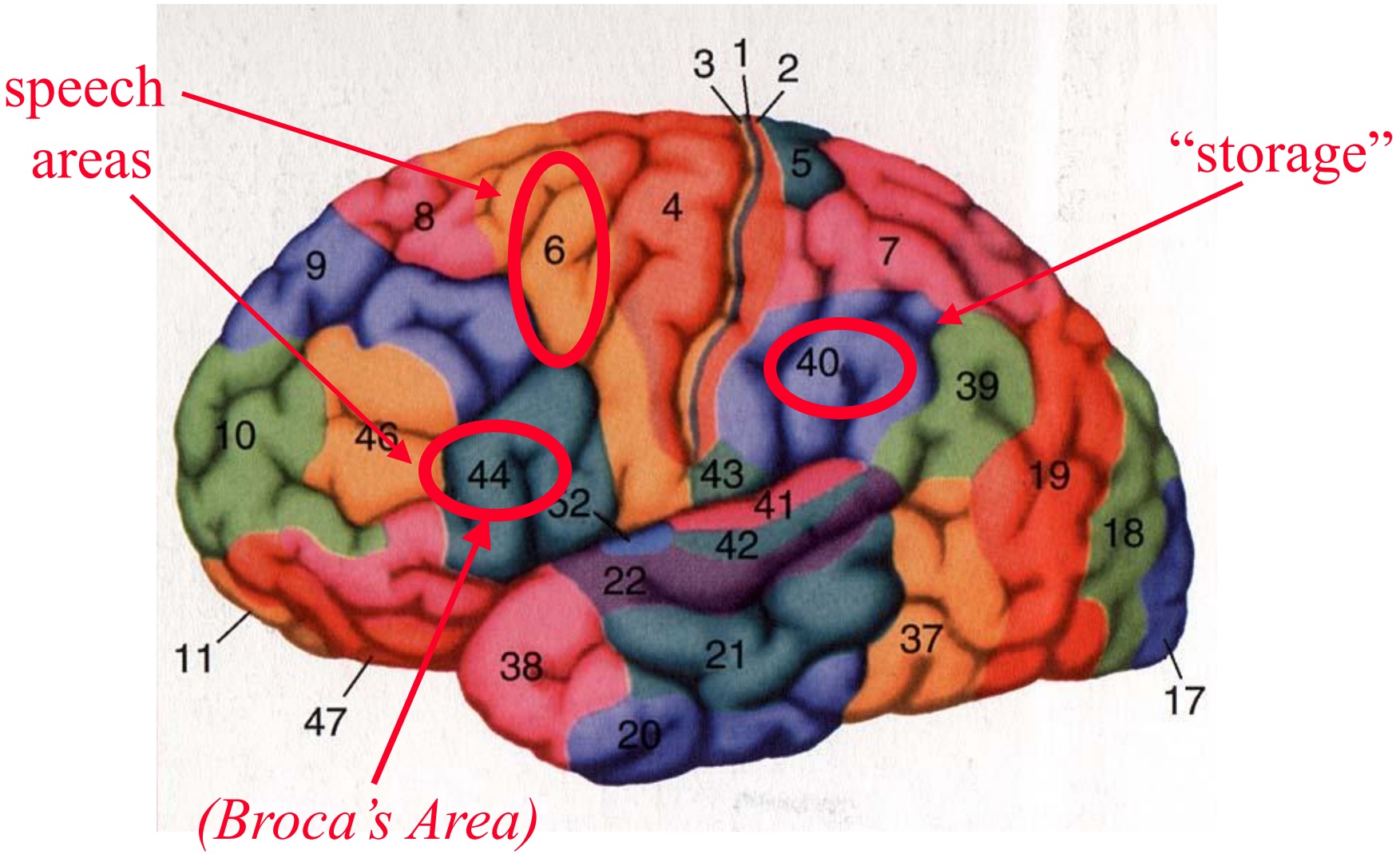
- Verbal Working Memory Task:



500 ms *200 ms* *3000 ms or 0 ms* *Respond*

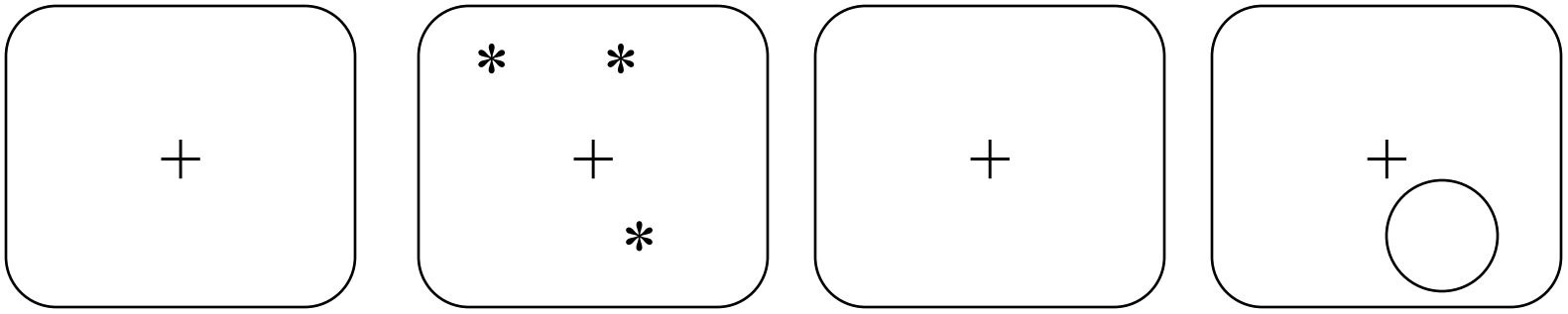
(e.g., Smith and Jonides, 1998)

Neural Basis of Verbal Working Memory



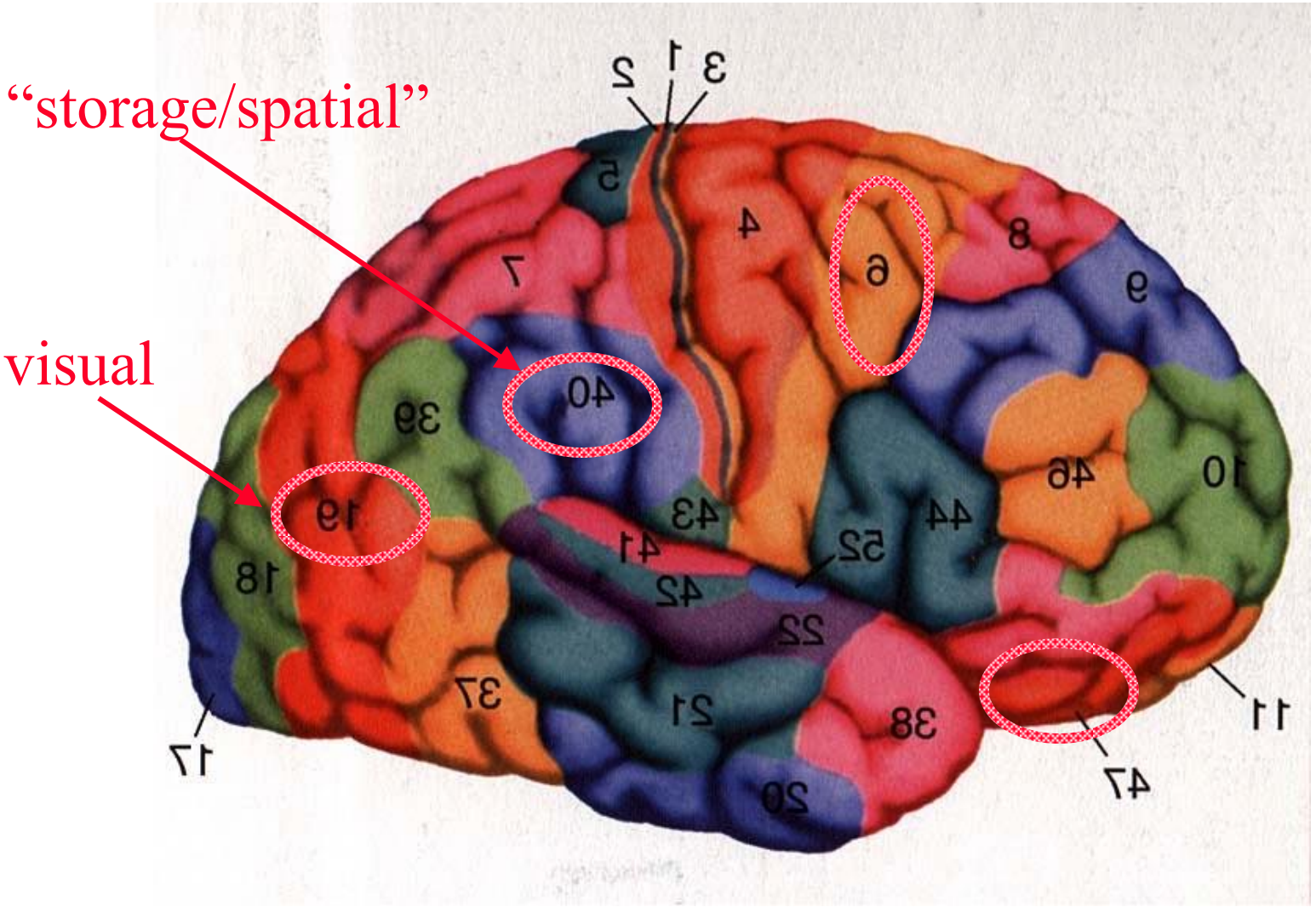
Neural Basis of Working Memory

- Spatial Working Memory Task:



500 ms *200 ms* *3000 ms or 0 ms* *Respond*

Visio-Spatial Working Memory in Right Hem.



Summary

- Transfer to long-term memory is not about rehearsal, but about elaboration (depth of processing)
- The trick to remembering stuff is associating it with other stuff (even artificially)
  - This works even on the huge scale of memorizing 80+ digits, and explains how people seem to hold inordinate amounts of information in their heads sometimes

Next Time: Semantic memory (i.e. conceptual structure)