

# Cognitive Psychology

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Lecture 4: Short-term memory and working memory

# Outline for today

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## Memory

- Sensory Memory
- Short-term Memory
- The Serial Position Effect
- Working Memory (the new STM)
  - Phonological Loop
  - Visuospatial sketchpad
  - Central Executive
  - Episodic Buffer

# What is Memory?

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## Processes involved in ...

1. retaining,
2. retrieving, and
3. using

... information about stimuli, images, events, ideas, and skills after the original information is **no longer present**

**Active any time** some past experience has an impact on how you think or behave now or in the future

# What do we use memory for?

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- Mental time travel
- Prospective memory
- Facts
- Skills
- Hold information in mind

# Modal Model of Memory

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## **Atkinson and Shiffrin (1968)**

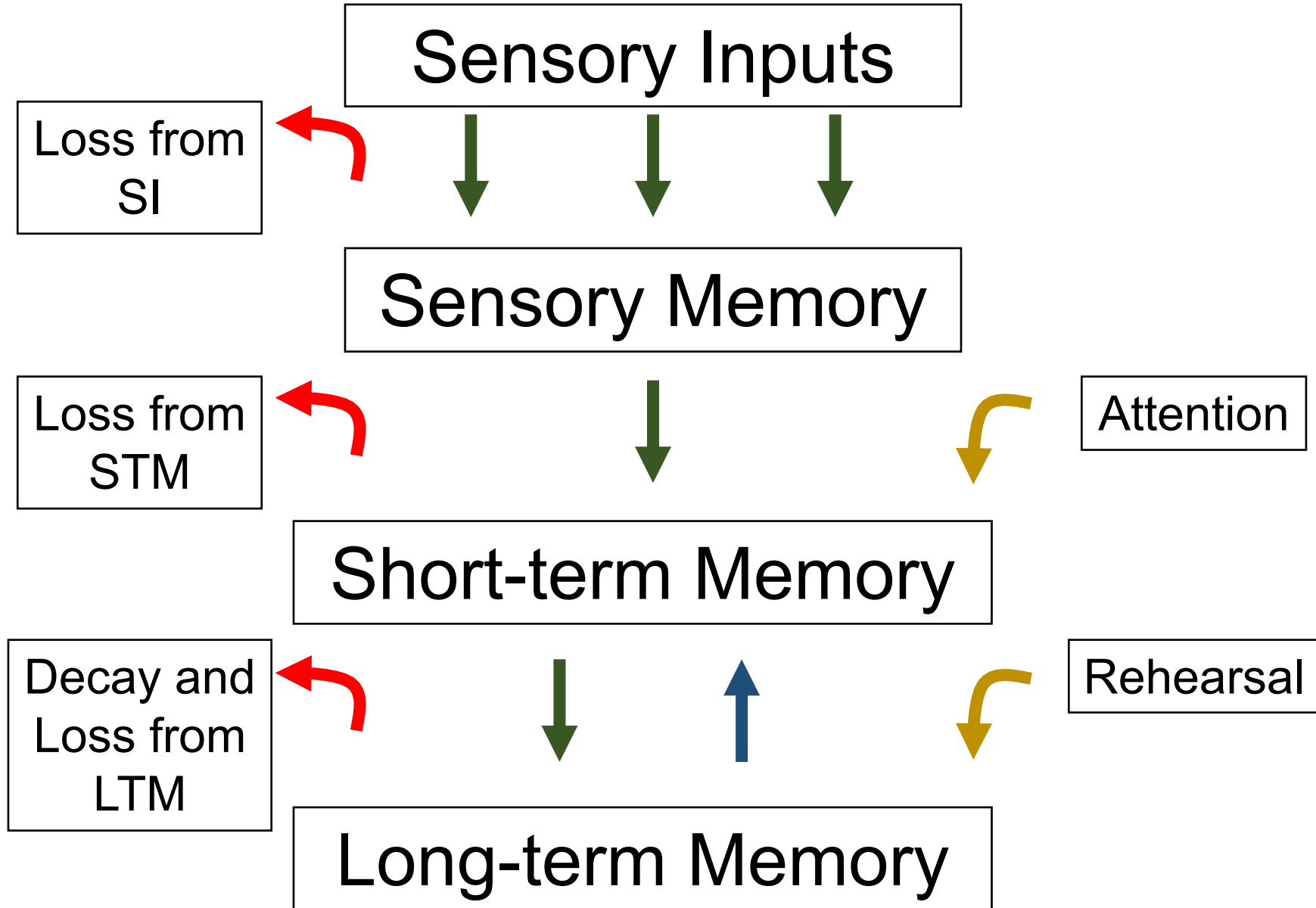
- Memory is an integrated system that processes information
  - Acquire, store, and retrieve information
  - Components of memory do not act in isolation
- Memory has a limited capacity
  - Limited space
  - Limited resources
  - Limited time

# Modal Model of Memory

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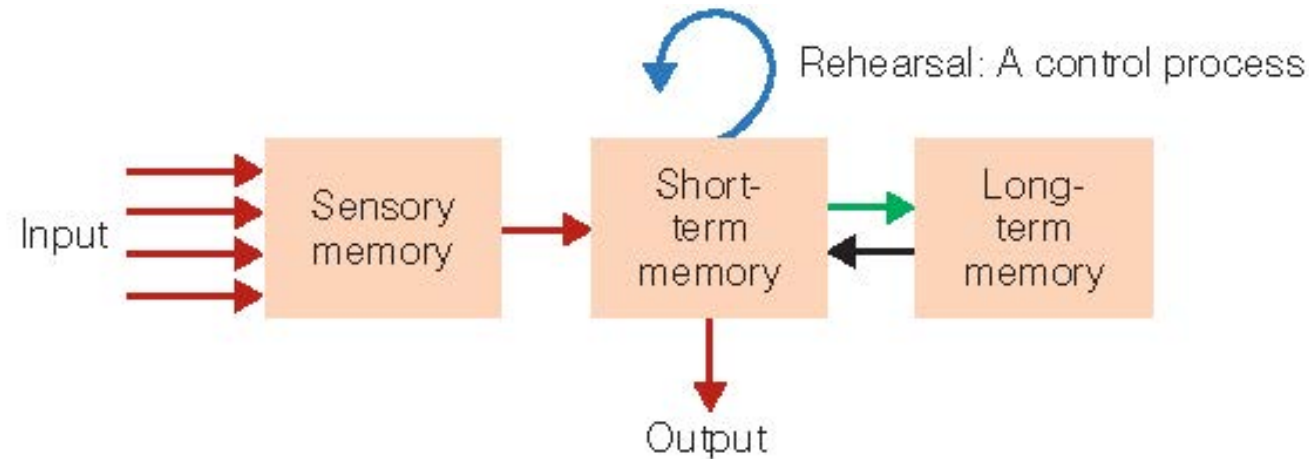
## **Atkinson and Shiffrin (1968)**

- Three different types of memory:
  1. Sensory Memory – Initial stage that holds all incoming information for seconds or fractions of a second
  2. Short-term Memory – Holds five to seven items for about 15 to 20 seconds.
  3. Long-term Memory – Can hold a large amount of information for years or even decades



# Modal Model of Memory

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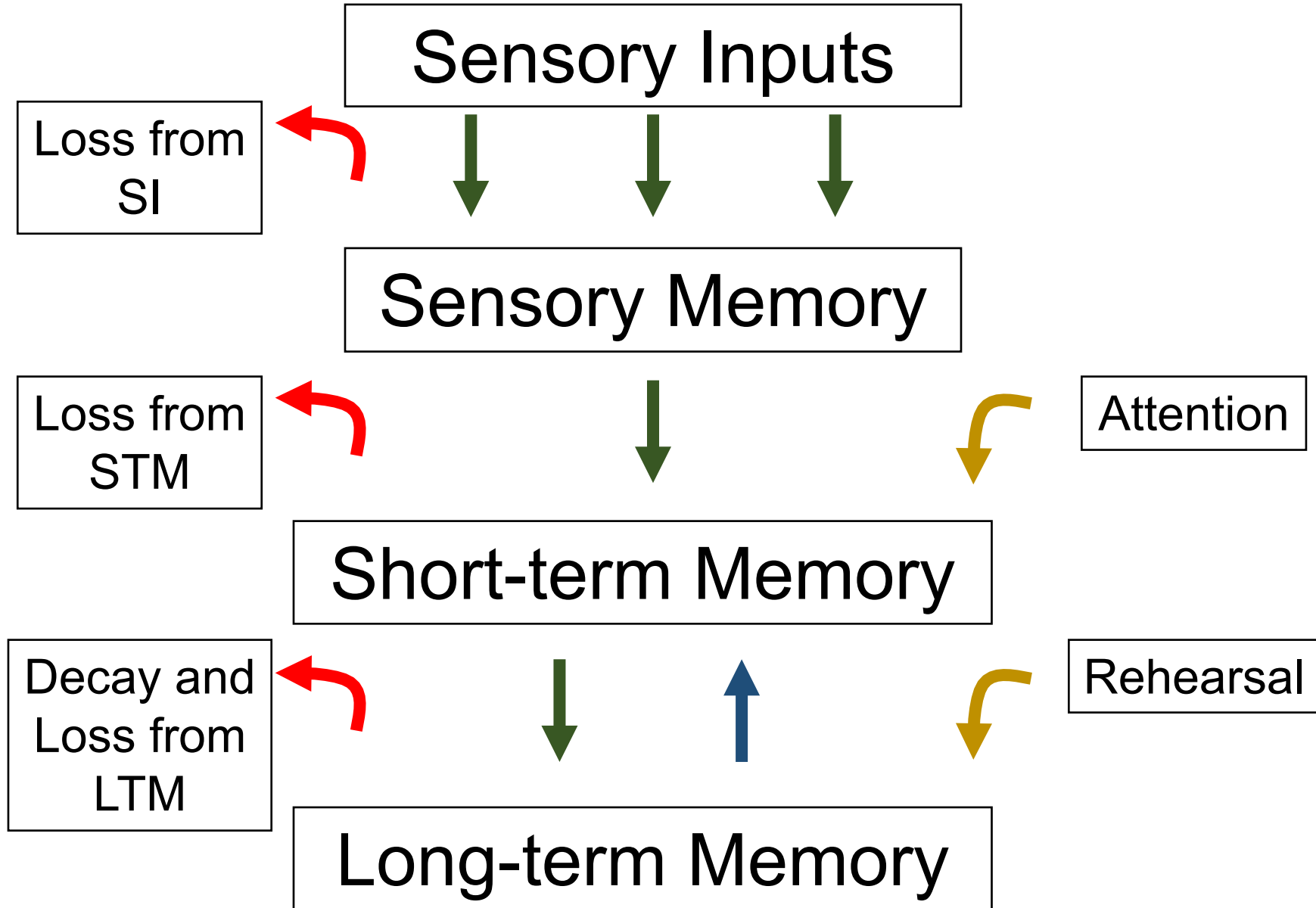
**Figure 5.2** Flow diagram for Atkinson and Shiffrin's (1968) modal model of memory. This model, which is described in the text, is called the modal model because it contained features of many of the memory models that were being proposed in the 1960s. © Cengage Learning



# Modal Model of Memory

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- Control processes: active processes that can be controlled by the person
  - Rehearsal
  - Strategies used to make a stimulus more memorable
  - Strategies of attention that help you focus on specific stimuli



# Sensory Memory

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- Initial repository of information
- Very primitive form of memory
- Some information from this store enters longer term memory
- Information disappears quickly if not passed on for further processing



# Sensory Memory

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- Sensory Memory: The retention, for brief periods of time, of the effects of sensory stimulation.
  - Information decays very quickly
- Persistence of vision: retention of the perception of light
  - Sparkler's trail of light
  - Frames in film



# Sensory Memory

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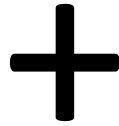
## Sperling, 1960

What is the capacity and duration of our sensory memory?

- Partial report versus whole report methods
- Whole Report Method:
  - Flash array of letters (50 ms)
  - Report as many as you can



G	F	A	L
I	Q	R	Y
P	E	B	O



Z C R T  
P O Q I  
S U N A

# Sensory Memory

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## Sperling, 1960

- Accuracy on whole report = 37.5% (4.5 / 12 letters)
- But why?
  - H1: Our sensory memory capacity is limited to 4.5 items
  - H2: Sensory memory is larger than 4.5 items, BUT fades so quickly that by the time you've reported 4 items, you've forgotten the others



Z C R T  
P O Q I  
S U N A



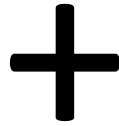
# Sensory Memory

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## Sperling, 1960

- Partial Report Method:
  - Flash array of letters (50 ms)
  - Report the row indicated by a tone
    - Important: Participant cannot predict which row they will need to report
    - Can vary the delay between array and tone
    - We'll use a red flash





O T E R

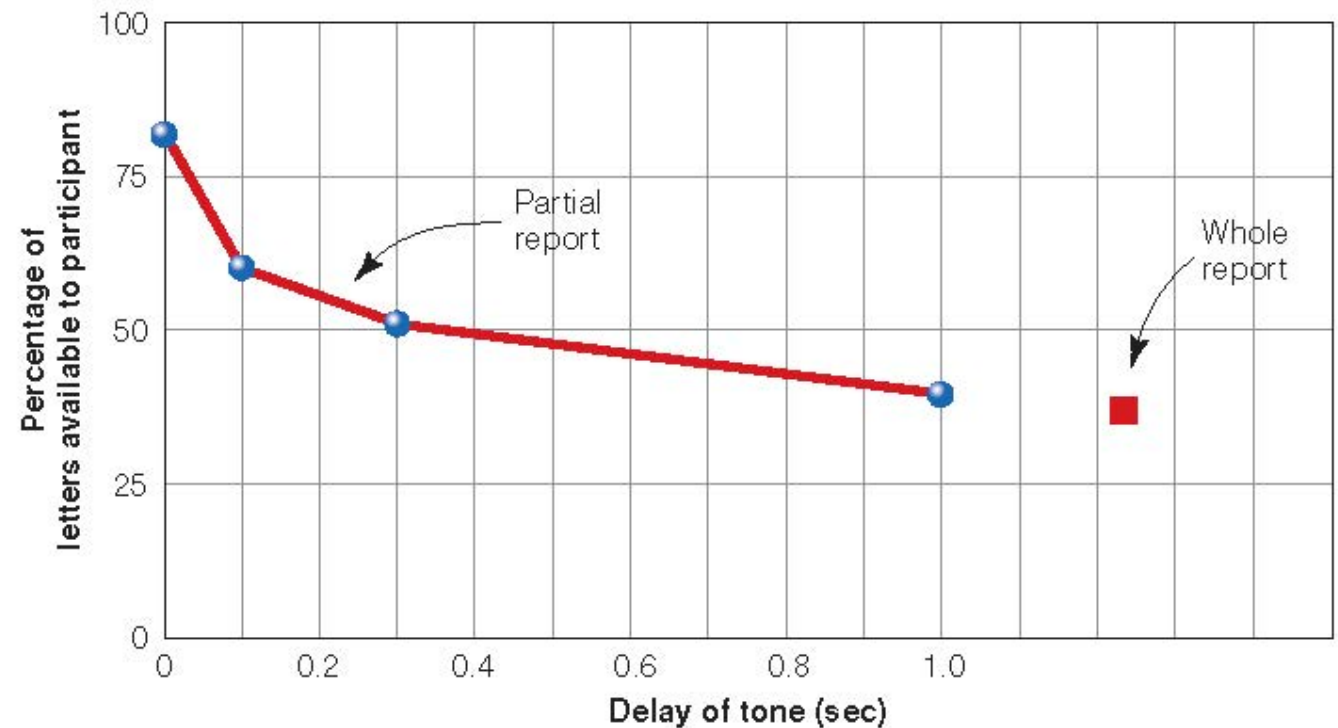
L M Q I

J H F Y

# Sensory Memory

## Sperling, 1960

- Partial Report
  - Can report >75%
  - Accuracy decreases with increasing delays between array and cue



**Figure 5.6** Results of Sperling's (1960) partial report experiments. The decrease in performance is due to the rapid decay of iconic memory (sensory memory in the modal model). © Cengage Learning

# Sensory Memory

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## Iconic Memory

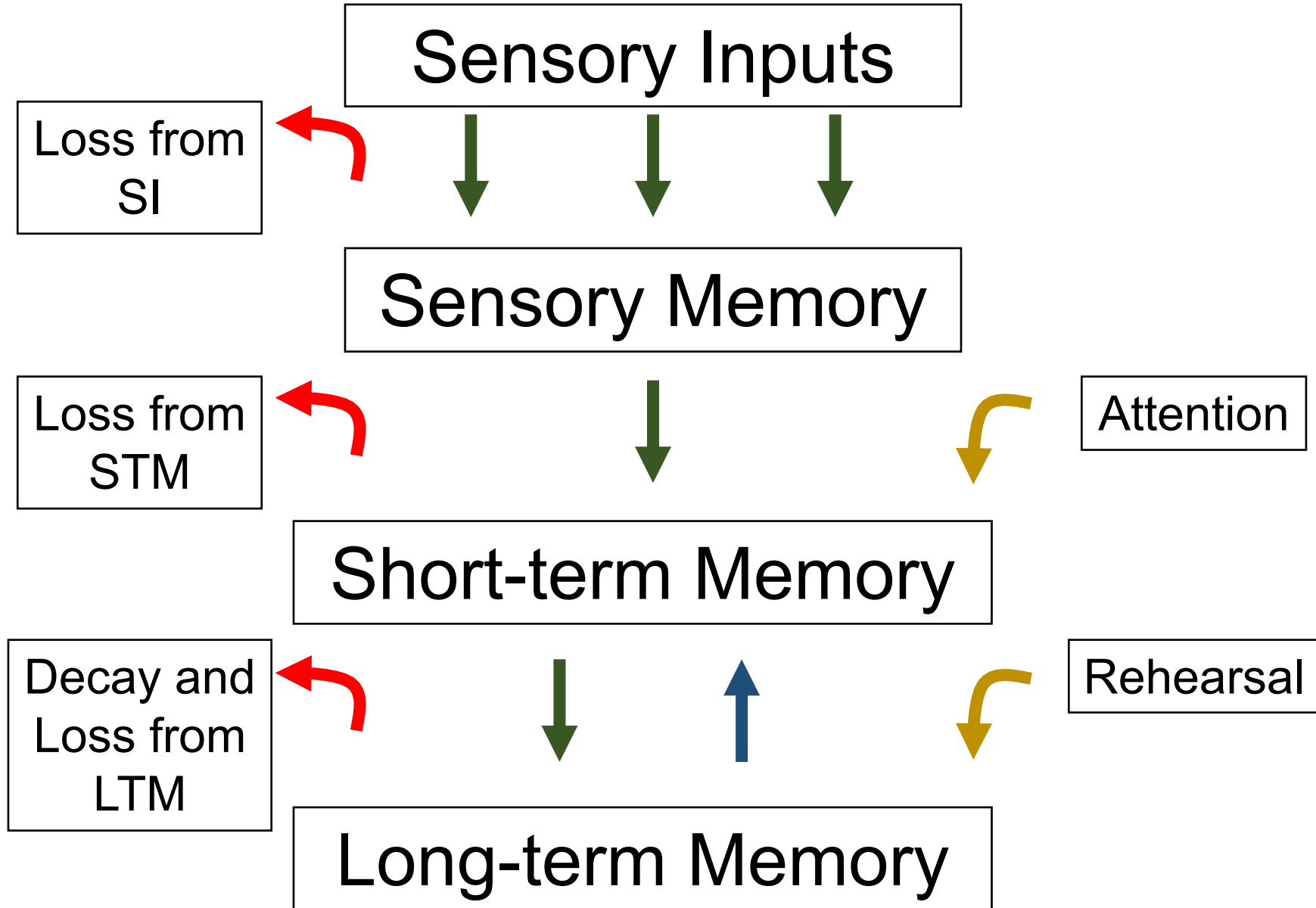
- Sensory memory for visual information
- Lasts about 250 ms (up to 1 sec)
- Maximum capacity may be limitless, but estimates are around 9 to 10
- Sperling's partial report technique

# Sensory Memory

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## Echoic Memory

- Sensory memory for auditory information
- Lasts between 250 ms to 3 sec and information is accurately represented
- Capacity? – Probably large, but measured to be around 5 items



# Short-term Memory

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- Stores small amounts of information for a brief duration
  - Lasts about 12-18 seconds
  - Capacity is seven plus or minus two
  - More often auditory than visual
  - Rehearsal to prevent decay
- Includes both new information received from the sensory stores and information recalled from long-term memory



# Short-term Memory

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- Clive Wearing
  - Sensory & Short-Term Memory Only
  - <http://www.youtube.com/watch?v=Vwigmktix2Y>

# Short-term Memory

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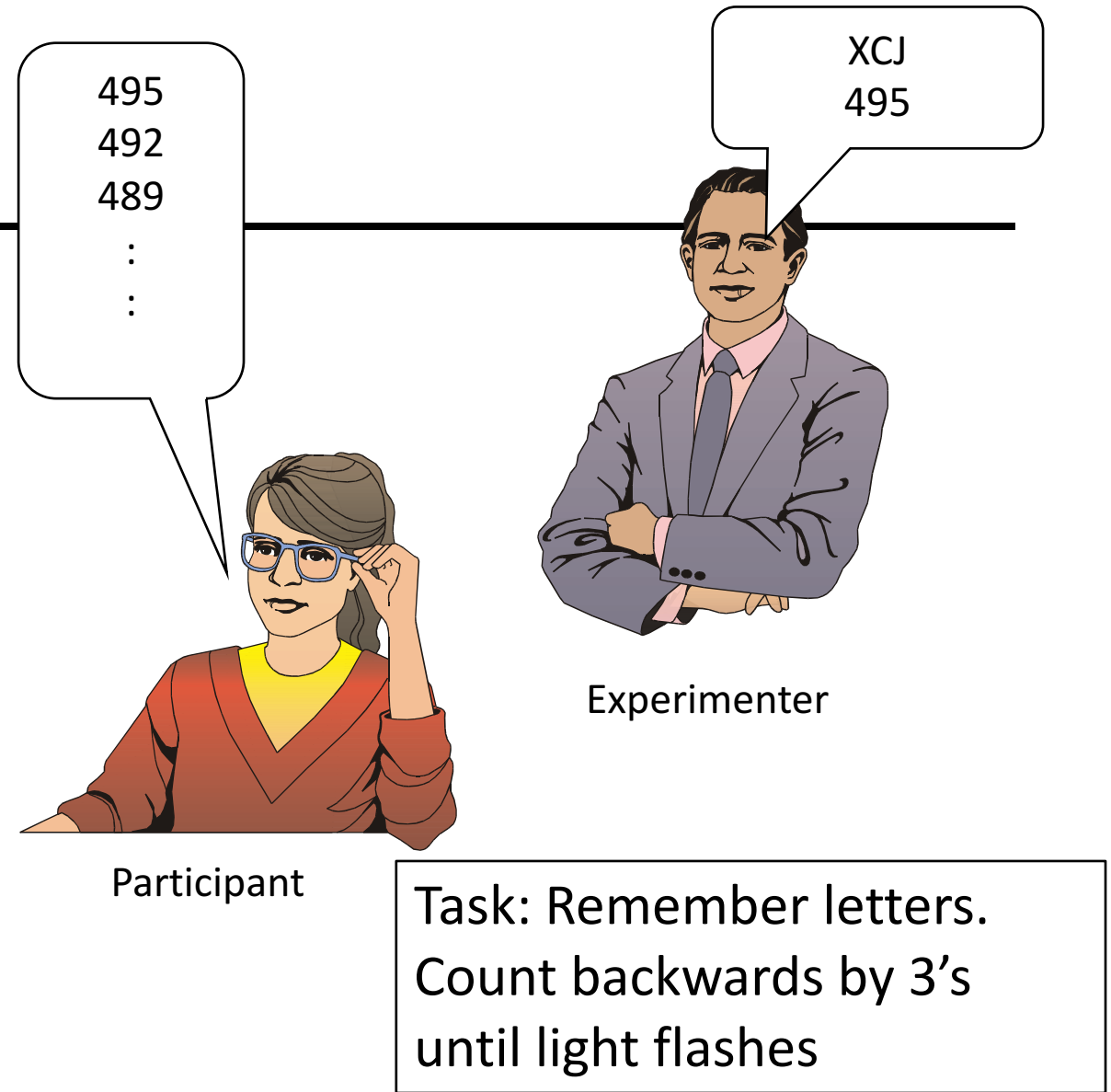
The “capacity” of short-term memory can be thought of in terms of:

- 1. Duration**
- 2. Number of “items”**
- 3. Amount of “information”**

# Short-term Memory

## Peterson & Peterson, 1959

- Measuring the capacity of short-term memory in terms of duration

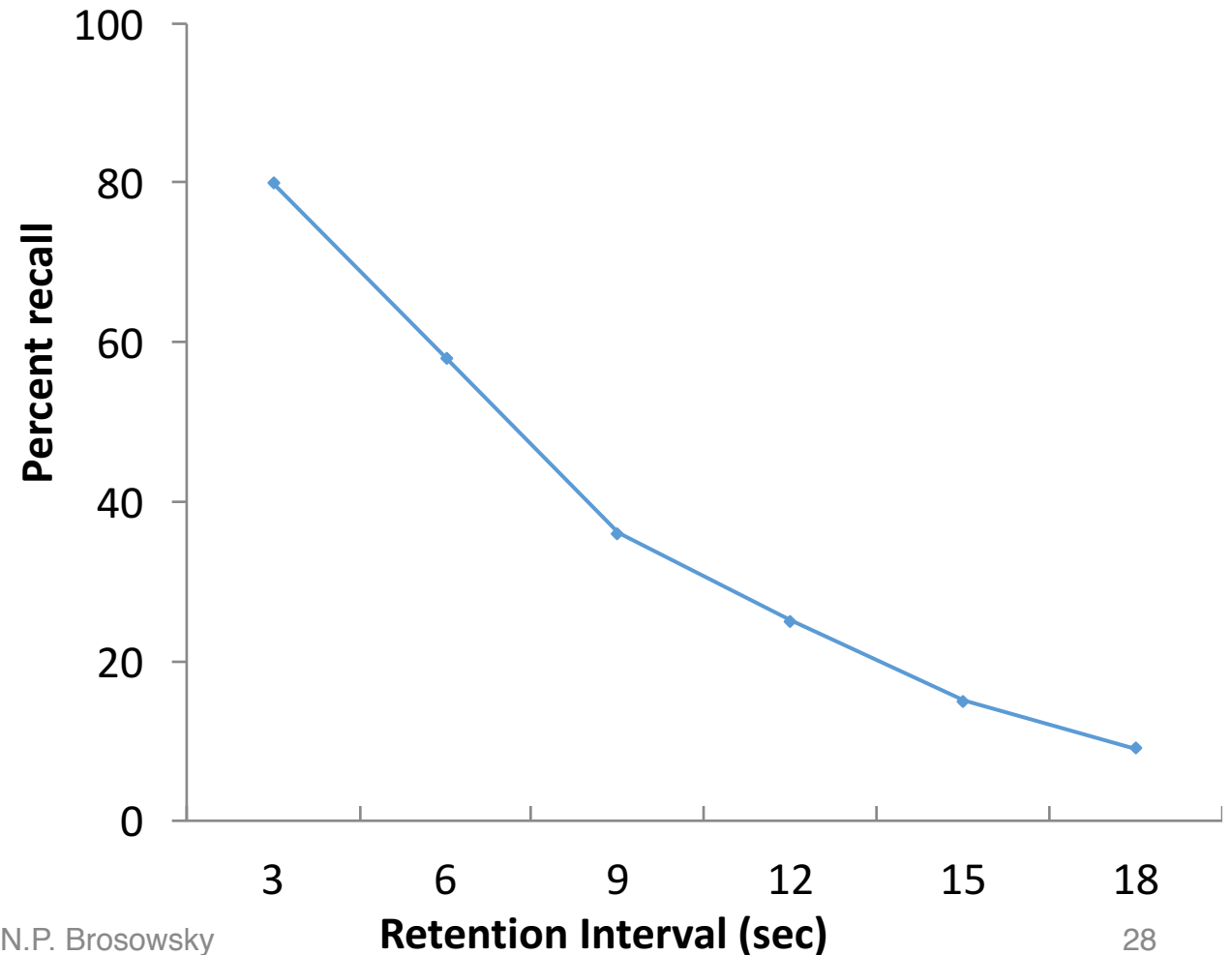


# Short-term Memory

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## Peterson & Peterson, 1959

- Performance < 10% after 18 seconds of counting
- Originally explained as the result of “decay”



# Short-term Memory

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**The duration of short-term memory, when rehearsal is prevented, is about 15-20 seconds**

# Short-term Memory

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## Why does short-term memory become worse over time?

H1: Decay of the memory trace

H2: Interference from other memories/information

- **Proactive interference:** occurs when information learned previously interferes with learning new information
- **Retroactive interference:** occurs when new learning interferes with remembering old learning

# Short-term Memory

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## Waugh & Norman, 1965

- Present long strings of numbers
- Report the number following the initial presentation of the last probe digit
  - E.g., “5 3 7 4 2 9 3 4 6 2 6 3 4 6 3 0 2 (tone)”
  - The correct response would be 9

# Short-term Memory

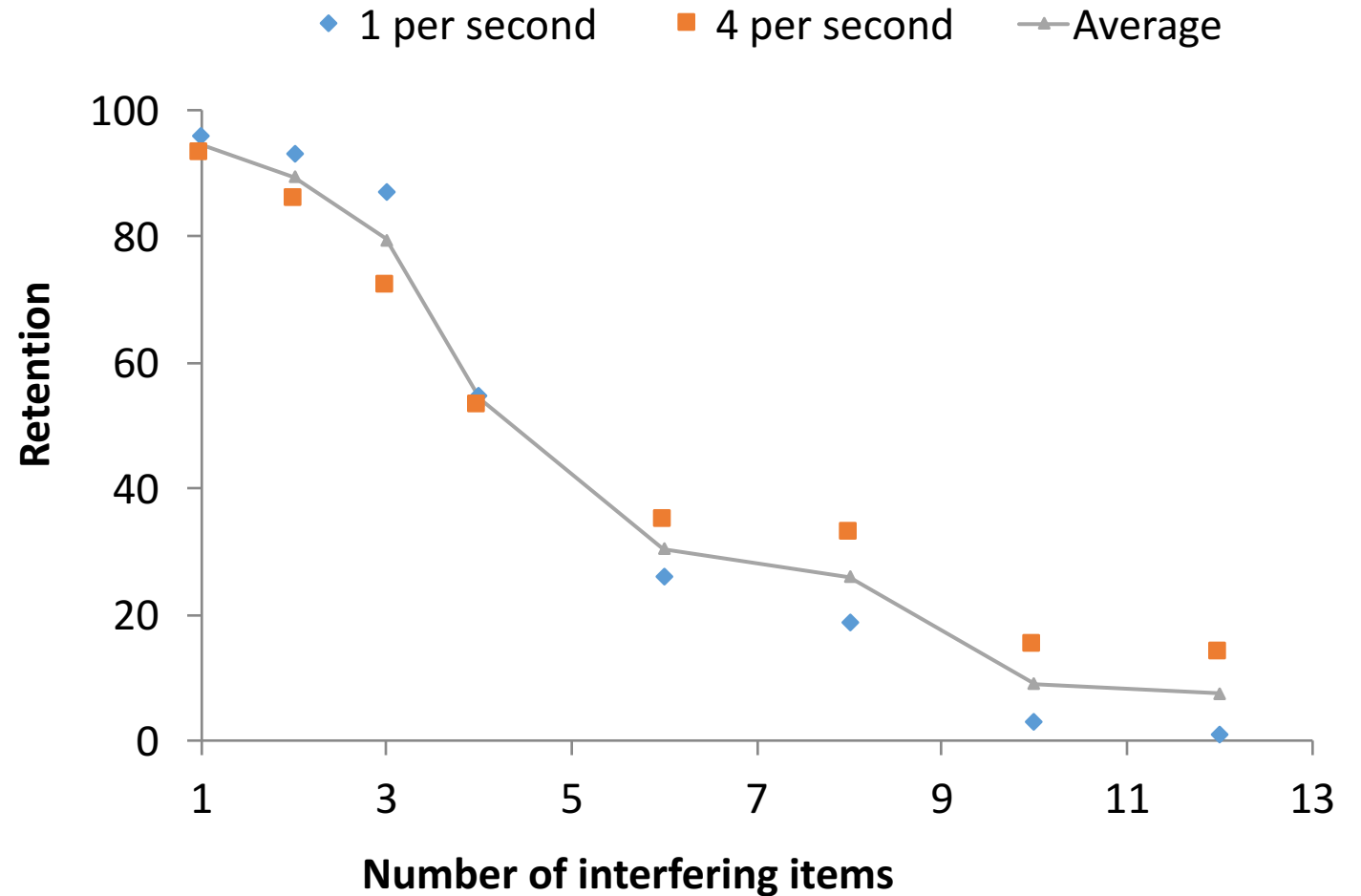
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## Waugh & Norman, 1965

- Manipulated the number of intervening numbers & rate of presentation (speed)
- **If decay, then** performance will be better at a faster rate because there is less time for memory to decay
- **If interference, then** worse performance with increasing number of items, regardless of the rate of presentation



1. Performance decreases as you have more items
2. Did not matter how fast items were presented



# Short-term Memory

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**The duration of short-term memory, when rehearsal is prevented, is about 15-20 seconds**

**The limited duration seems to be due to proactive interference**

- Lecture example: Waugh & Norman, 1965
- Textbook example: Keppel & Underwood, 1962
  - (reanalyzed the Peterson and Peterson data)

# Short-term Memory

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- Measuring the capacity of short-term memory in terms of “items”
  - Digit span: how many digits a person can remember
  - Typical result: 5-8 items
    - The Magic Number 7!

# Short-term Memory

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**But what is an “item”?**

**The letter span task**

- Try remembering:

**XIBMSATMTVPHDX**



# Short-term Memory

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- Try to write down as many of them as you can
- Did you get all 14 of them?
  - 14 exceeds capacity of STM
  - Capacity  $7 \pm 2$
- What strategy did you use?

# Short-term Memory

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- Chunking: small units can be combined into larger meaningful units
  - Capacity:  $7 \pm 2$  chunks, not items
  - Group several items together into meaningful units of information
- Try remembering this:

XIBMSATMTVPHDX

# Short-term Memory

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- Ericsson et al. (1980)
  - Trained a college student with average memory ability to use chunking
    - S.F. had an initial digit span of 7
  - After 230 one-hour training sessions, S.F. could remember up to 79 digits
    - Chunking them into meaningful units



# Short-term Memory

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## **Measuring the capacity of short-term memory in terms of “information”**

Alvarez and Cavanaugh (2004)

- Used colored squares as well as complex objects
- Used the change detection procedure



100 ms

(a)



900 ms delay



2,000 ms  
Same or different?



100 ms

(b)



900 ms delay

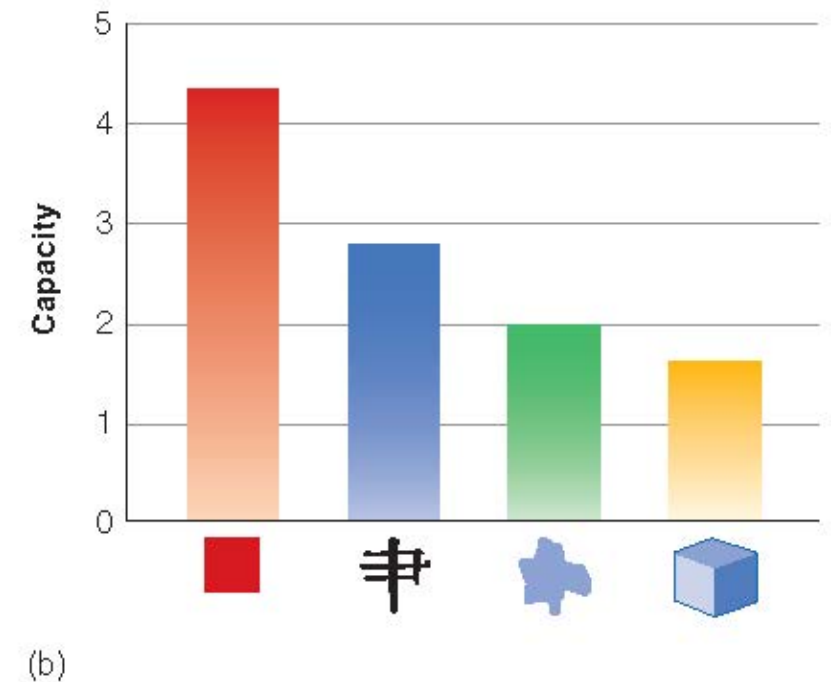
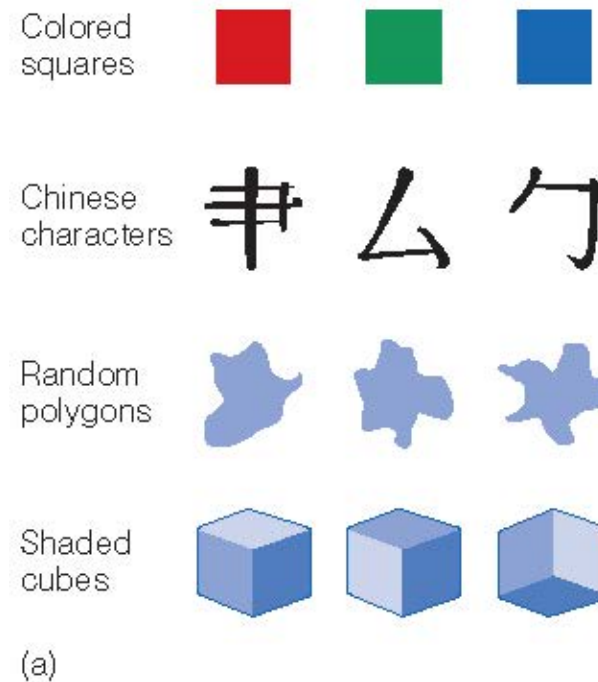


2,000 ms  
Same or different?

# Short-term memory

Alvarez and  
Cavanaugh (2004)

- # of items depends on the complexity of the information



# Short-term Memory

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## What is the capacity of short-term memory?

- Duration: 15-20 seconds, when rehearsal is prevented
- Number of items: 7 +/- 2 chunks
  - “items” are flexible, and can be “chunked”
- Amount of Information: Complexity of information can impact the number of items that can be stored

# Short-term Memory summary

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- Modal Model
  - Short-Term Memory
    - Limited Capacity
      - Chunking to Increase
      - Proactive Interference
    - Short Duration (15-20 sec)
    - Auditory, Visual, and Semantic Codes
  - Primarily understood as a storage system
  - STM memory is a way station from sensory to LTM

# STM is out, working memory is in

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- Doesn't explain all of the data
- Doesn't address dynamic processes
  - Manipulating information
- Doesn't explain how we can do 2 things at once
- Textbook example: remember a number while reading some text
  - Turns out, we can do this no problem

# Working Memory

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- Developed by Baddeley to address various shortcomings of the STM concept
  - Baddeley and Hitch (1974)
- A limited-capacity system for storing temporary information and manipulation of information for complex tasks such as comprehension, learning, and reasoning
- Contents might originate from sensory inputs or from LTM

# Working Memory

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## Working memory differs from STM

### Short-term Memory

- STM is a single component
- STM holds information for a brief period of time

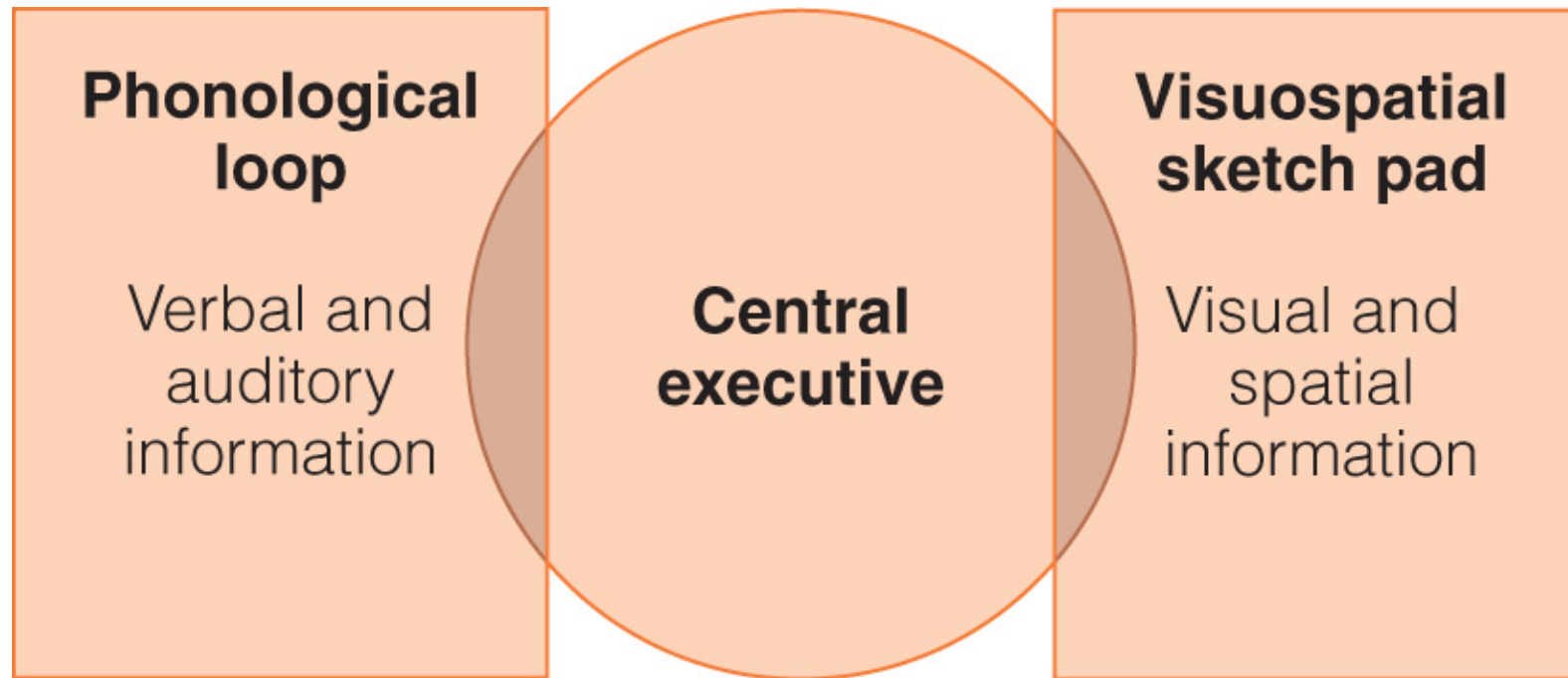
### Working Memory

- WM consists of multiple parts
- WM is concerned with the processing and manipulation of information that occurs during complex cognition



# Working Memory

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**Baddeley's working memory model**

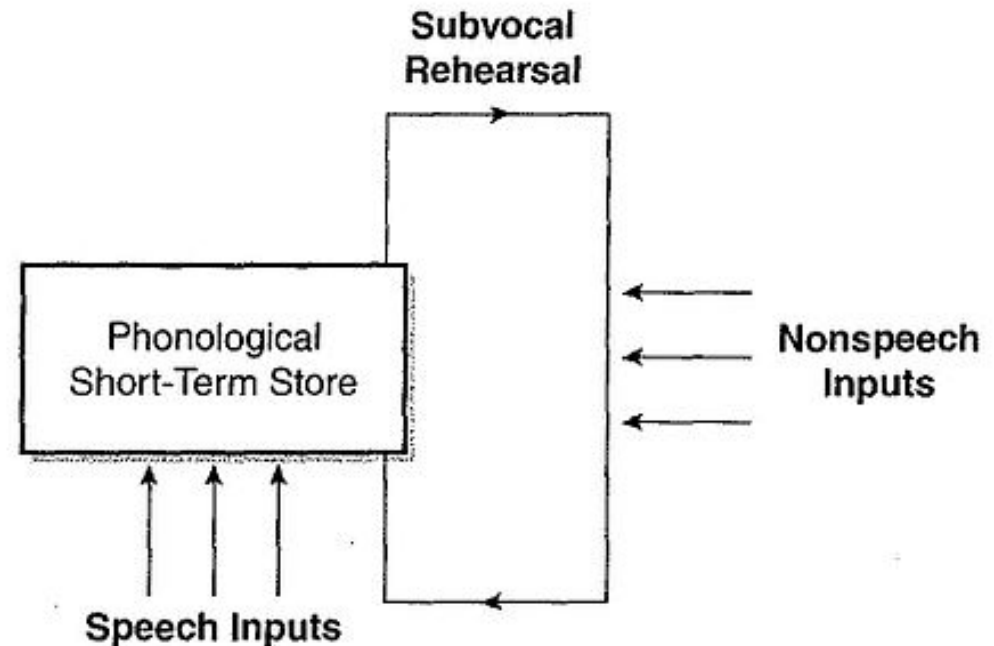
(c)2011 Cengage Learning

# Working Memory

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## The Phonological Loop

- Responsible for storing and rehearsing speech-based information
- May have two parts: A short-lived acoustic store and an articulatory component (subvocal rehearsal=loop)

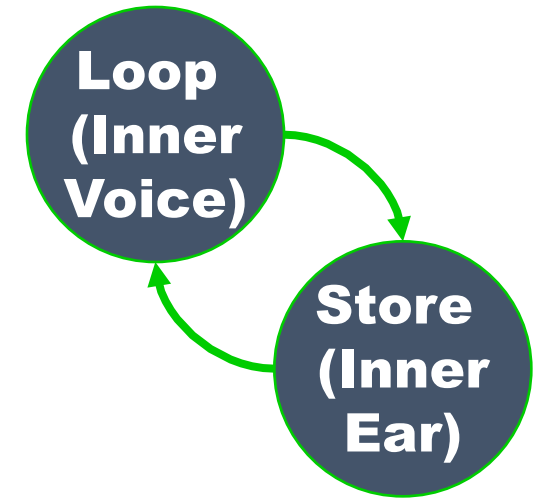
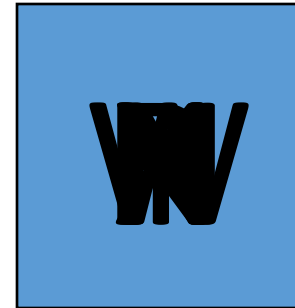


# Working Memory

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## The Phonological Loop

- Phonological similarity effect
  - Demo 1: Similar



**ANSWER:**  
**RHXKYWN**

*The point:*

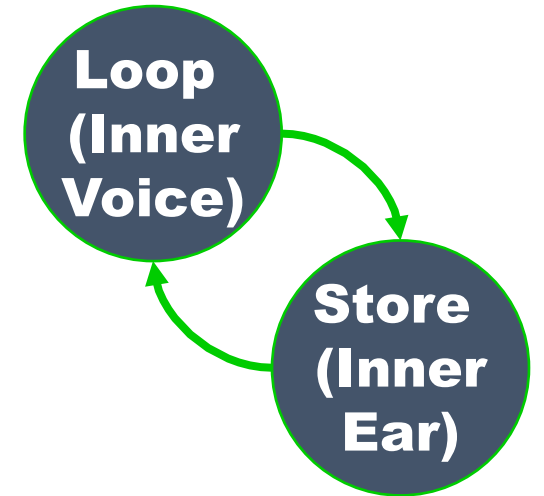
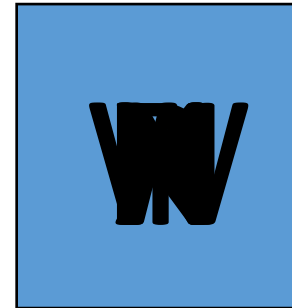
Immediate recall is impaired  
when items sound alike

# Working Memory

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## The Phonological Loop

- Phonological similarity effect
  - Demo 1: Dissimilar



**ANSWER:**  
**RHXKYWN**

*The point:*

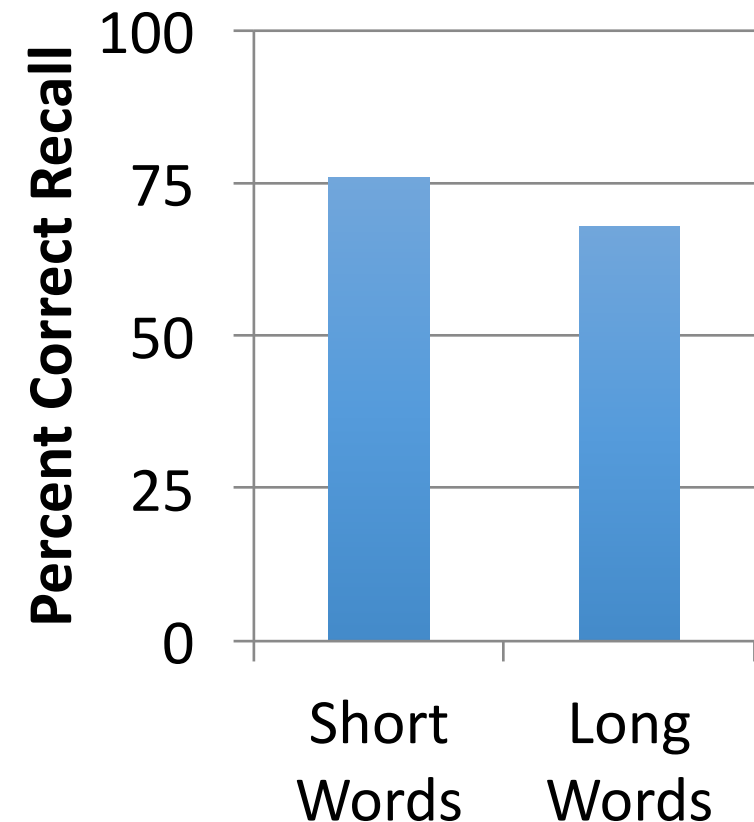
Immediate recall is impaired  
when items sound alike

# Working Memory

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## The Phonological Loop

- Word-length effect
  - Memory for lists of words is better for short words than for long words
  - Takes longer to rehearse long words and to produce them during recall

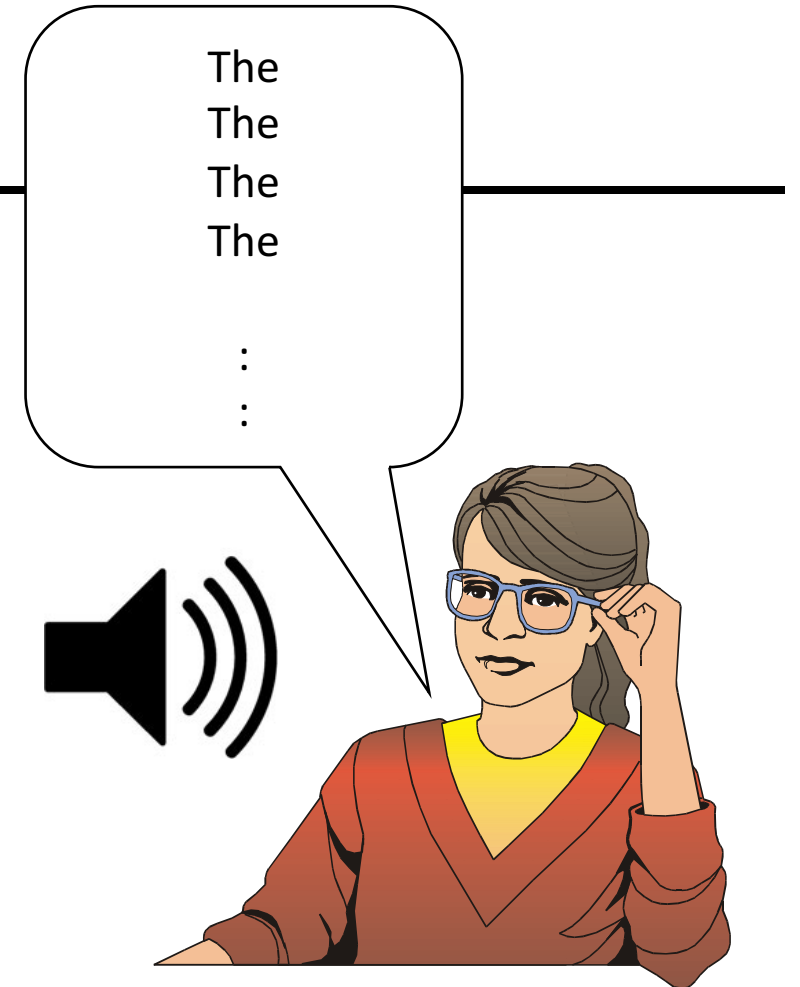


# Working Memory

## The Phonological Loop

Can we disrupt the phonological loop?

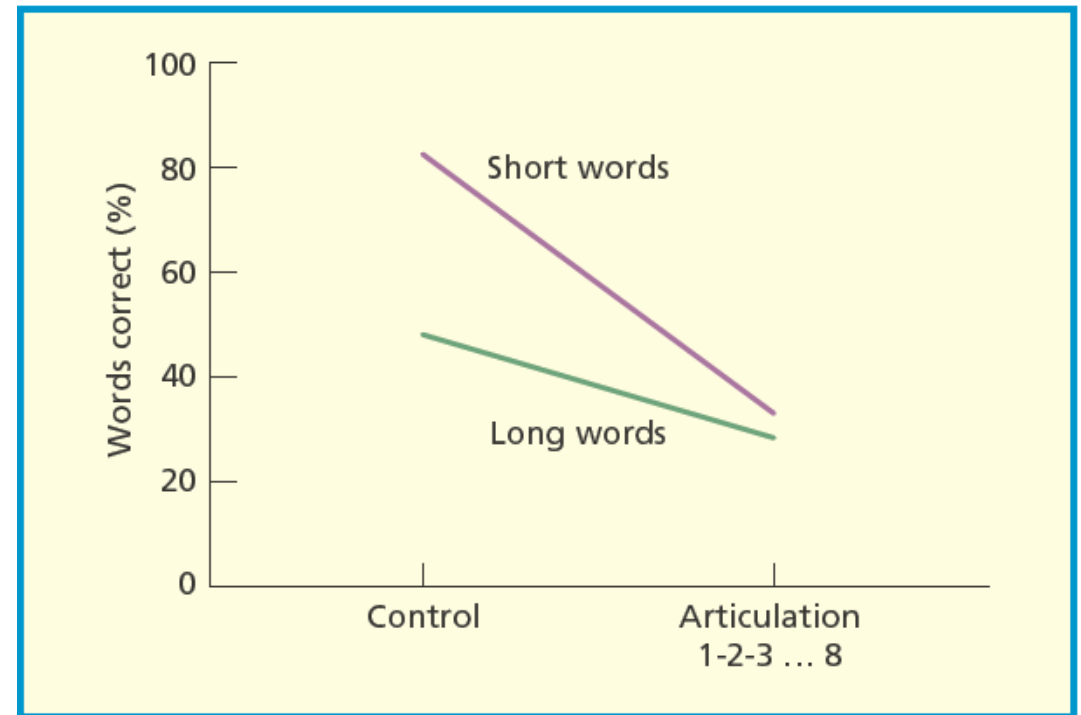
- Articulatory suppression
  - Prevents one from rehearsing items to be remembered
  - Logic
    - If articulation is related to verbal working memory, then articulation should eliminate short word advantage



# Working Memory

## The Phonological Loop

- Articulatory suppression
  - Prevents one from rehearsing items to be remembered
    - Reduces memory span
    - Eliminates word-length effect
    - Reduces phonological similarity effect for reading words



# Working Memory

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## The Visuospatial Sketchpad

- Involved with setting up and manipulating visuospatial material
- Visuospatial stimuli affects processing in the visuospatial sketchpad
- Likely to be used in mental imagery

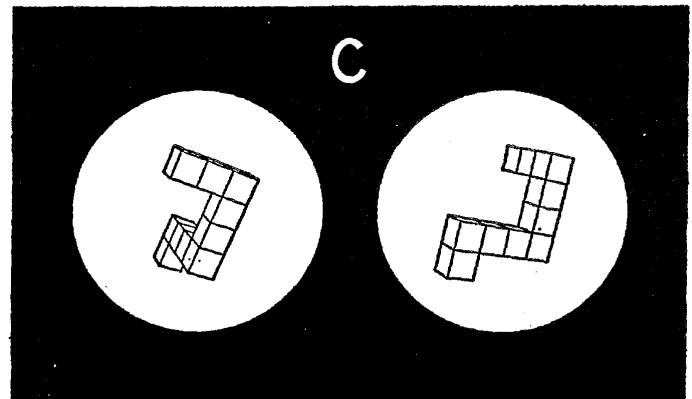
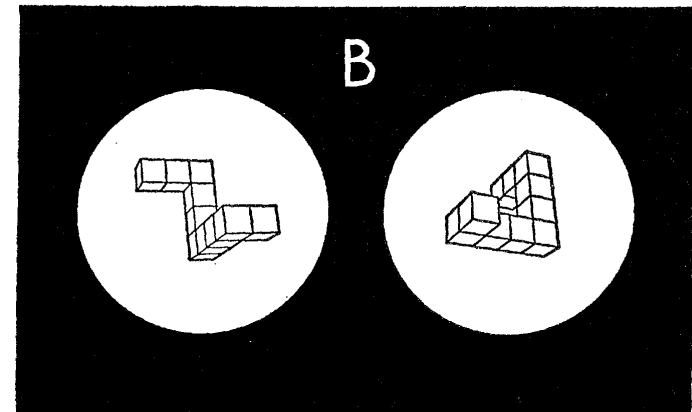
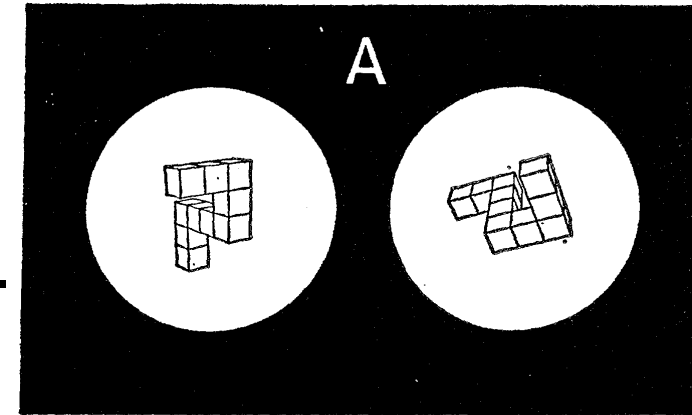


# Working Memory

## The visuospatial sketchpad

### Mental Rotation

- Task: Are the objects the same or different?
- Logic:
  - If Visual Images are “visual”, then mentally rotating should be similar to actual rotation

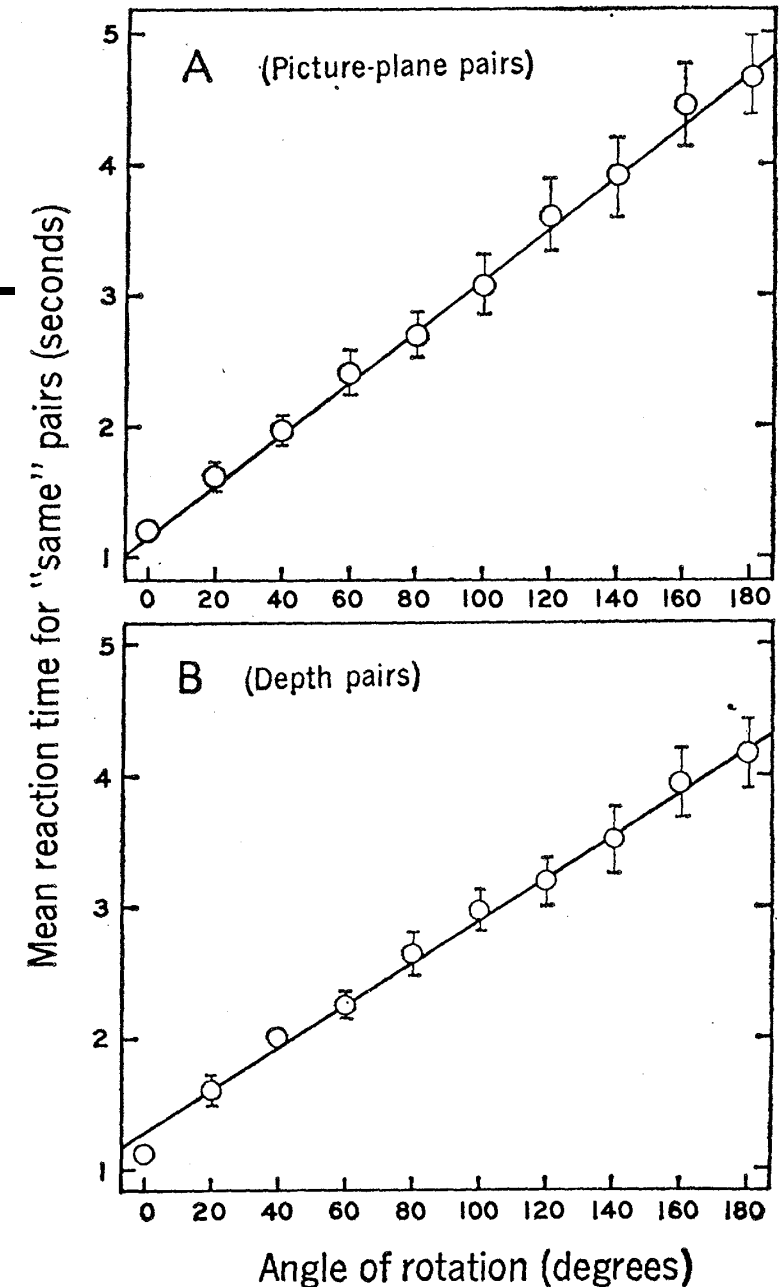


# Working Memory

## The visuospatial sketchpad

### Mental Rotation

- Response times increase as the angle difference increases
- **We have to actually rotate the objects in our mind in order to respond accurately**



# Working Memory

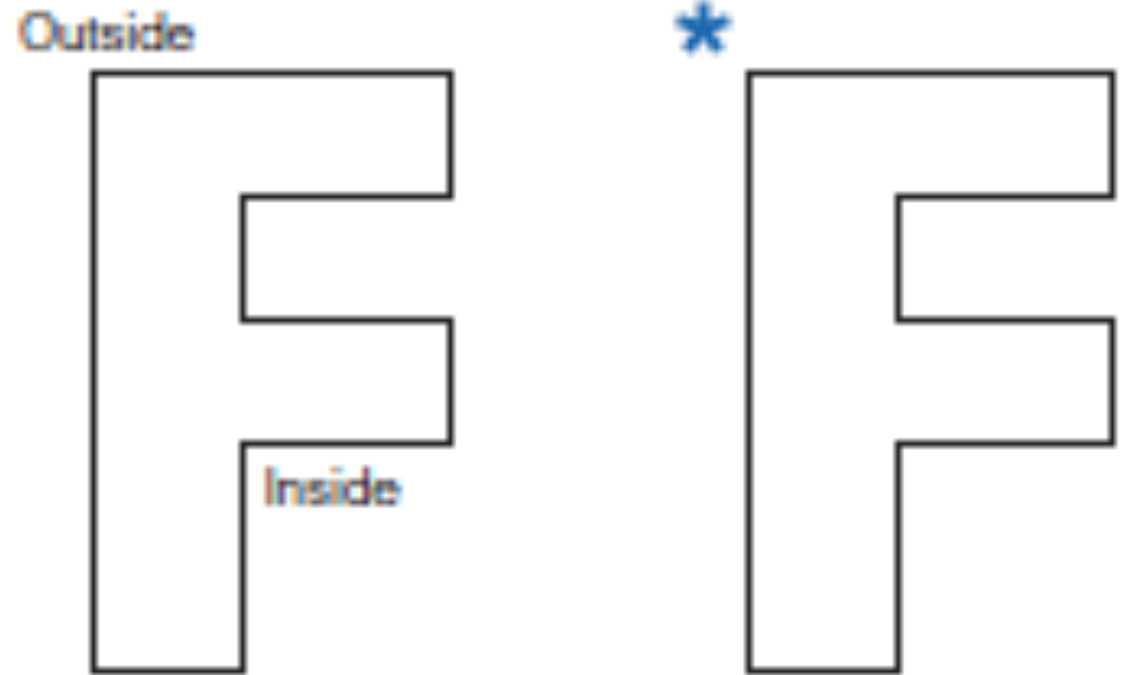
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## The visuospatial sketchpad

Can we disrupt the sketchpad?

### Brooks, 1968

- Visualize the “F” and follow the outline clockwise
- Only a visuospatial dual task should interfere with the sketchpad



# Working Memory

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- As you would predict, only a secondary spatial task disrupts

## Task 1: Verbal

- Say “out” whenever you hit a corner pointing out
- Say “in” whenever you hit a corner pointing in

## Task 2: Spatial

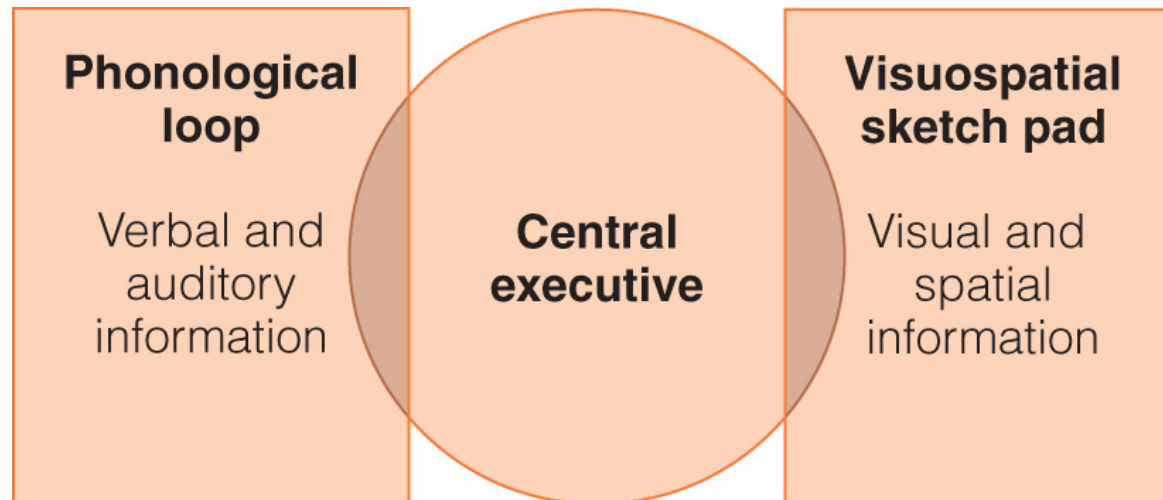
- Physically point to “out” / “in”

CORNER		POINT	
1	OUT	IN	
2	OUT	IN	
3	OUT	IN	
4	OUT	IN	
5	OUT	IN	
6	OUT	IN	
7	OUT	IN	

# Working Memory

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- WM is set up to process different types of information simultaneously
- WM has trouble when similar types of information are presented at the same time



**Baddeley's working memory model**

# Working Memory

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## **The Central Executive**

- Coordinates information from the slave systems; command-and-control center
- Modality non-specific, i.e. independent of different sensory modalities
- Attention-controlling system involved with novel circumstances, also coordinates and plans activities

# Working Memory

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## The Central Executive

- Attention controller
  - Focus, divide, switch attention
- Controls suppression of irrelevant information
- Perseveration: repeatedly performing the same action or thought even if it is not achieving the desired goal

# Working Memory

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## Revisions to the Working Memory model

The addition of the episodic buffer

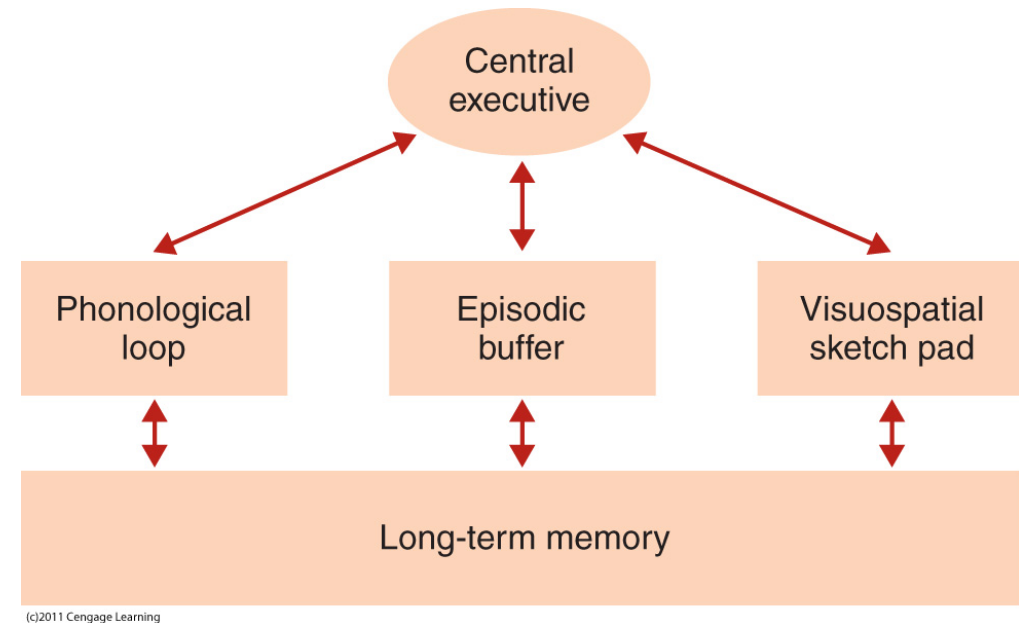
- Backup store that communicates with LTM and WM components
- Hold information longer and has greater capacity than phonological loop or visuospatial sketch pad



# Working Memory

## The Episodic Buffer

- Temporary (buffer)
- Integrates information between the phonological loop, sketchpad, and LTM
- Controlled by the central executive
- Transfers information into and out of the long term store.
- Provides a clearer connection to be made between working memory and long-term memory.



# Take Home Messages

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- Modal Model of Memory
- Baddeley's Working Memory Model
  - Improves on Modal Model
  - Working Memory Works
    - Maintenance & Manipulation
  - Four main components:
    - Central Executive
    - Phonological Loop
    - Visuospatial Sketchpad
    - Episodic Buffer