

# Sensory, short- term, and working memory

Image removed due to copyright restrictions.  
Cartoon involving long- and short-term memory.

Paymon Hosseini

10/10/2007

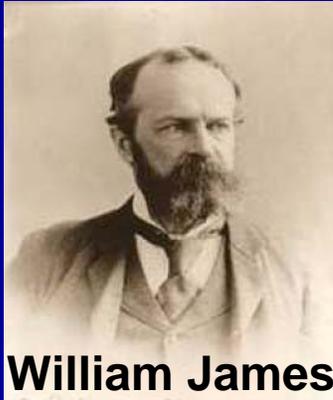
# Outline

- Review: memory is not monolithic
- Temporary memory systems
  - Evidence for short-term memory (STM)
  - Evidence for sensory memory
- How do temporary memory systems interact?
  - Atkinson-Shiffrin model of STM
  - Evidence against Atkinson-Shiffrin model
  - Baddeley-Hitch model of STM

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# Memory is not monolithic



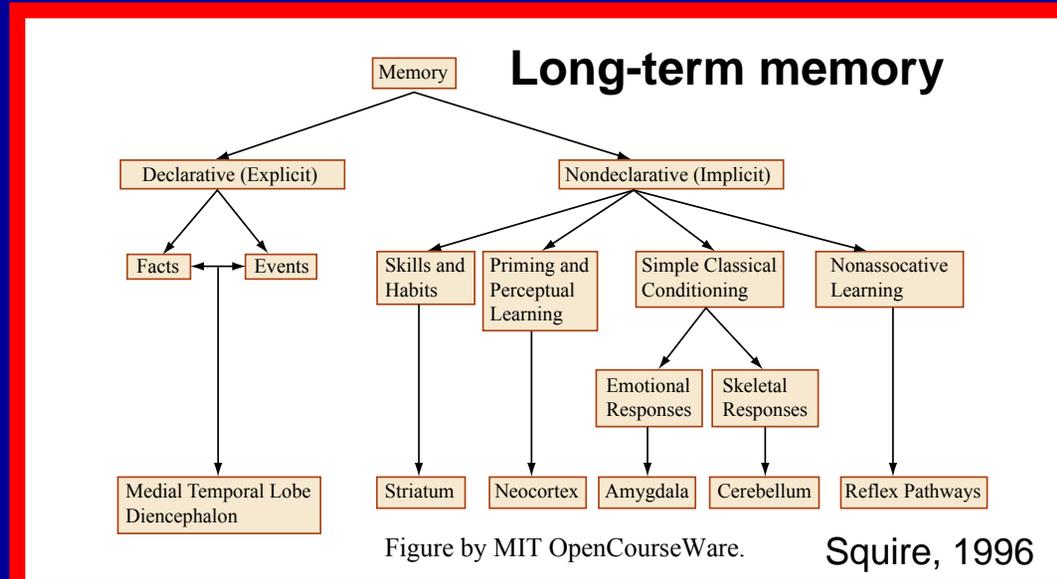
William James

## Secondary memory (LTM)

the knowledge of a former state of mind after it has already once dropped from consciousness

## Primary memory (STM)

information remaining in consciousness after it has been perceived



## Short-term memory



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# STM

Short-term memory (STM) refers to memory processes that retain information only temporarily, until information is either forgotten or becomes incorporated into a more stable, potentially permanent long-term store

- Memorize:

773-562-5519

# STM can be dissociated from LTM

- Capacity of short-term memory is limited
  - Miller, 1956
- Duration of short-term memory is brief
  - Peterson and Peterson, 1959
- Two storage mechanisms active in free recall
  - Glanzer and Cunitz, 1966
- Impact of neurological damage on STM
  - H.M.
  - K.F.
  - C.W.

# Capacity

- Memorize a sequence of
  - digits
  - letters
  - words
- Repeat in original order

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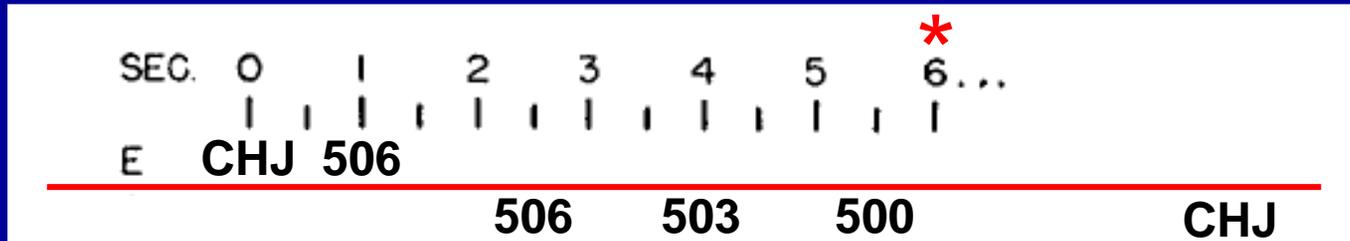
Span:  $7 \pm 2$  “chunks”

8 7 3 2 5 9 4 3 5 6

873          259      4356

Capacity of STM is limited

# Duration

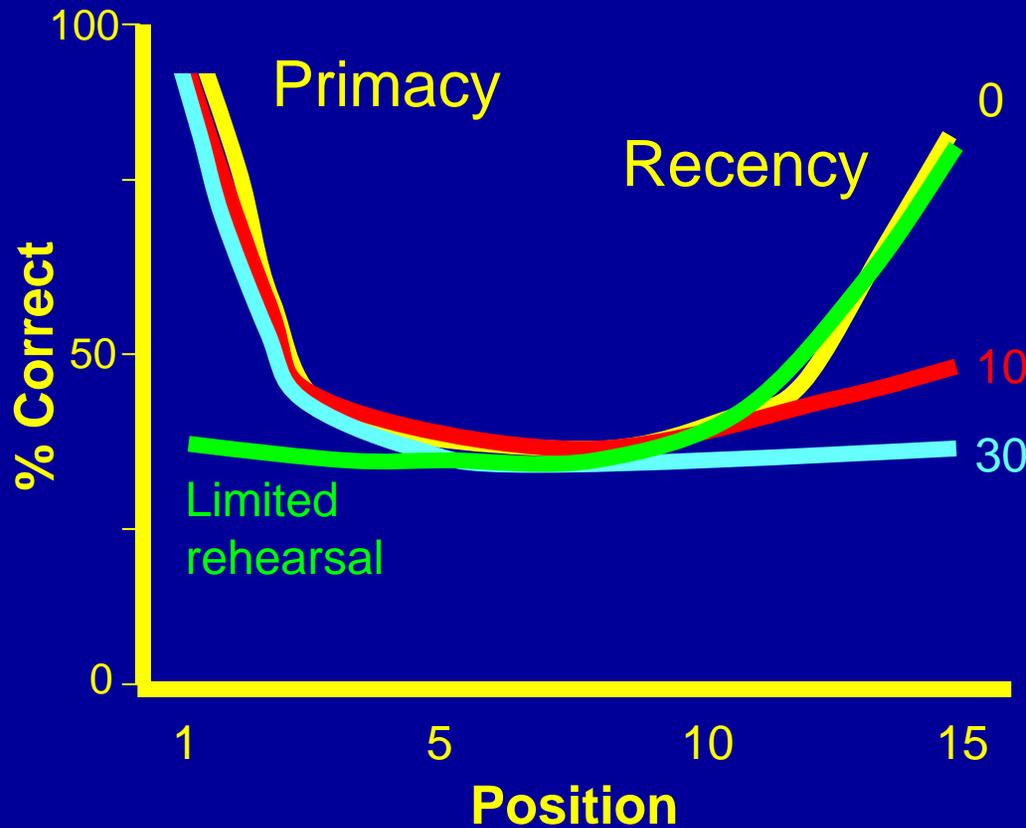


Without attention and rehearsal, information is lost rapidly from STM

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Graph of experimental results showing that as the length of time and amount of interfering verbal information increased between a stated cue and time of recall, frequency of correct cue recall exponentially decreased.

# Serial position effect in free recall



H,M,Q,D,P,G,L,K,W,F,Z,B,X,J,N

Rehearsal facilitates maintenance of information in STM and transfer of information from STM to LTM

# A double dissociation between LTM and STM

H. M. - Bilateral removal of medial temporal lobe structures

K. F. - Left temporo-parietal lesion

C.W. - Hippocampal lesion

	LTM	STM
H.M., C.W.	Cannot form new LTM	normal
K.F.	normal	digit span = 2

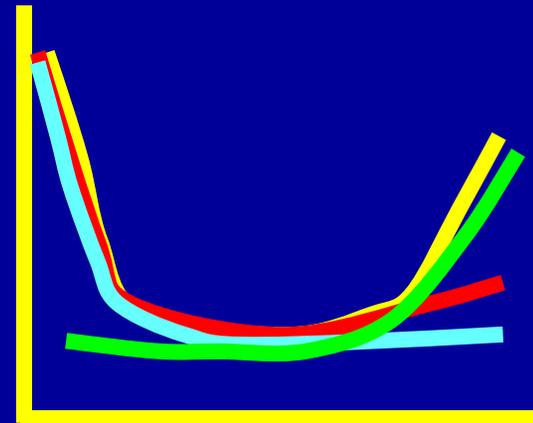
Short-term and long-term memory stores are distinct

# Short-term memory summary

- Limited capacity
- Short duration
- Lost quickly without attention and rehearsal
- Rehearsal facilitates transfer of information from STM to LTM

$7 \pm 2$  chunks

Image removed due to copyright restrictions.



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# Sensory memory

A large-capacity but very temporary holding device that allows people to choose which elements, from all of the stimuli arriving through their senses, should be further processed and stored



George Sperling



# Sensory memory



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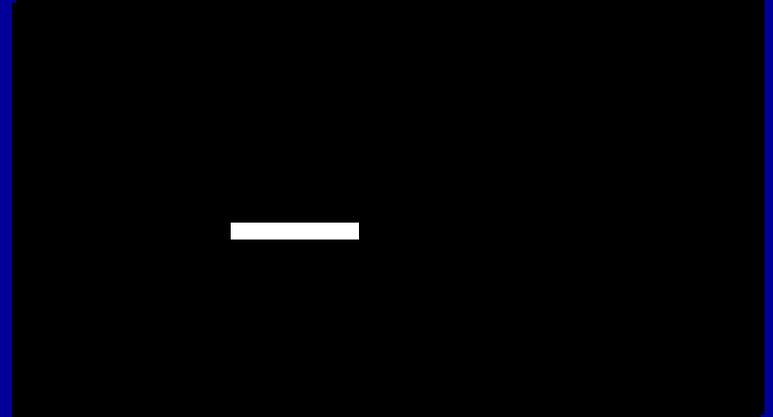
Given larger and larger matrices of letters, the ability to recall these letters maxes out at about 4.5 (averaged over 5 test participants).

A, K, E, W, D, T, Q, M, P, C, X, J

Q	B	F	Z	← High
X	E	G	K	← Medium
P	L	R	D	← Low

# Targeted Report Procedure

The partial report procedure is an improvement over the whole report procedure, but it does not solve the delay confound either



Targeted report procedure:

- After the presentation of a 3X4 array, one letter is underlined.
  - Participants report the underlined letter
- Very little loss due to time delay
- Memory capacity estimated to be at least 16-18 letters under optimal conditions

Capacity of iconic memory is large  
Iconic memory is lost rapidly without attention

# Duration of iconic memory

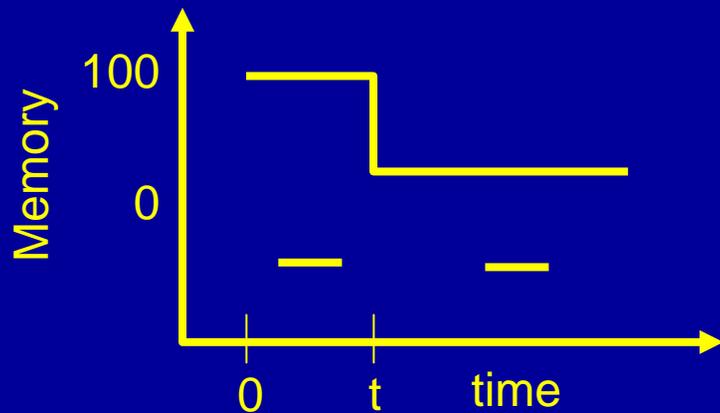


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Performance does not drop to chance because of contributions from STM, which operates on a longer time scale than iconic memory

Duration of iconic memory is roughly 200 ms

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# Temporary memory systems summary

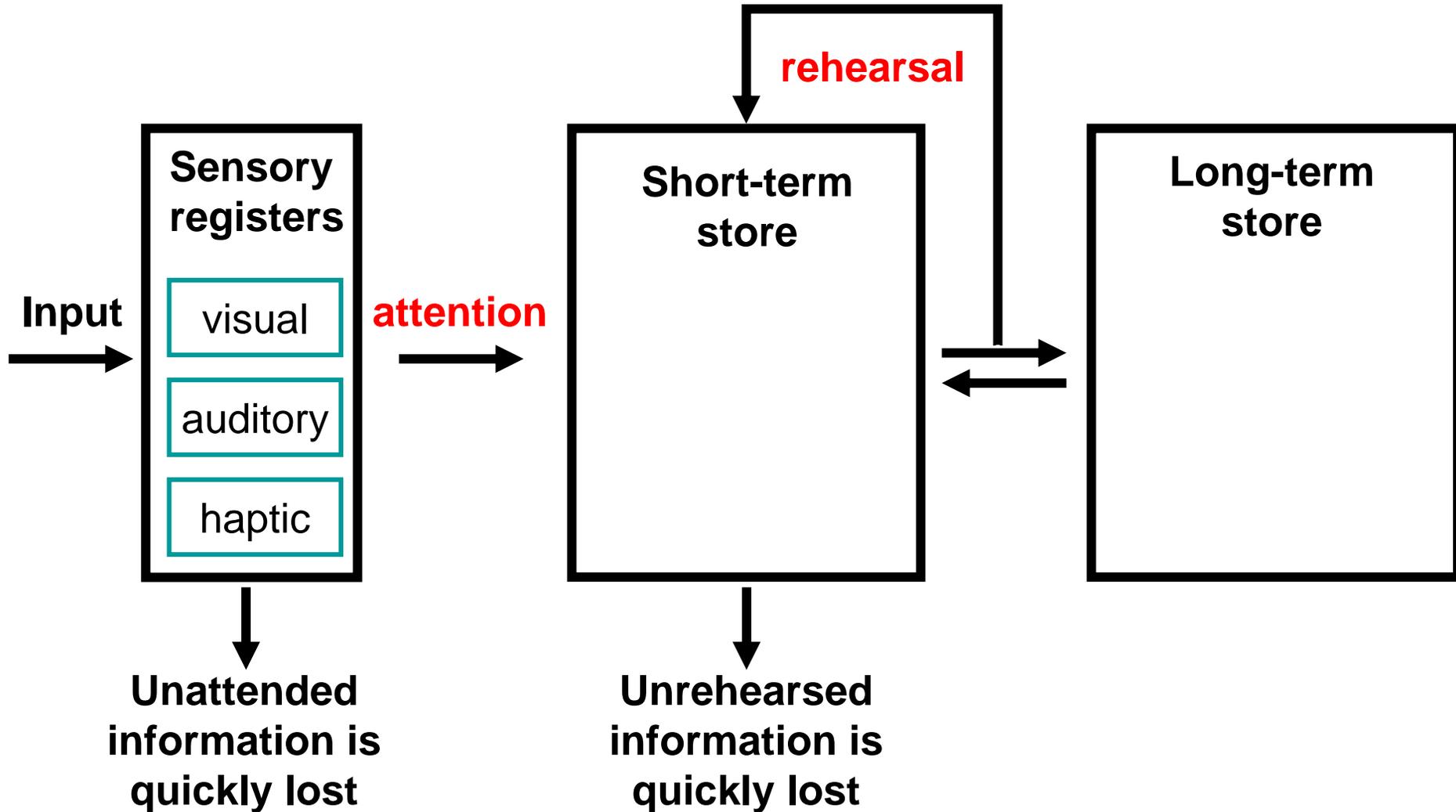
Sensory memory	Short-term memory	LTM
<ul style="list-style-type: none"><li>• Large capacity</li><li>• Modality-specific stores</li><li>• Very brief duration</li><li>• Lost rapidly w/o attention</li></ul>	<ul style="list-style-type: none"><li>• Limited capacity</li><li>• Short duration</li><li>• Lost without attention and rehearsal</li><li>• Rehearsal facilitates transfer to LTM</li></ul>	

**How can we combine this information into a coherent model of temporary memory systems?**

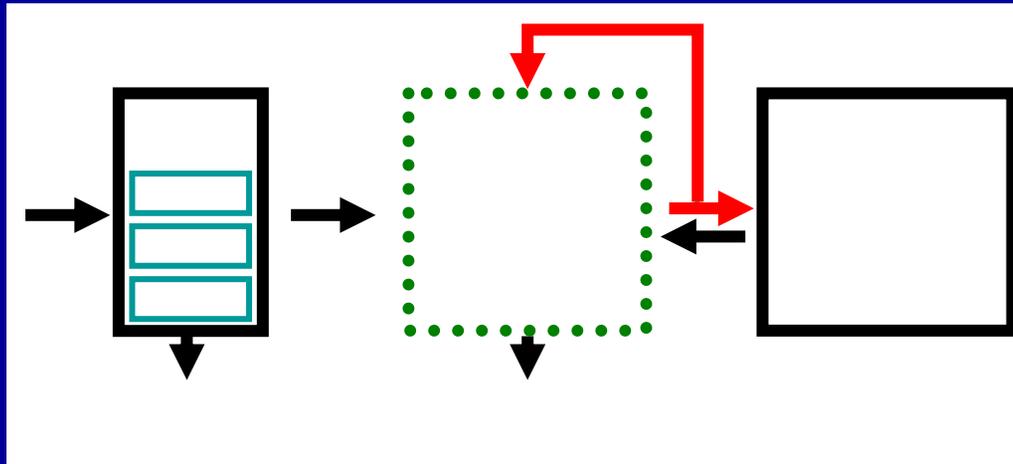
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# Atkinson-Shiffrin modal model



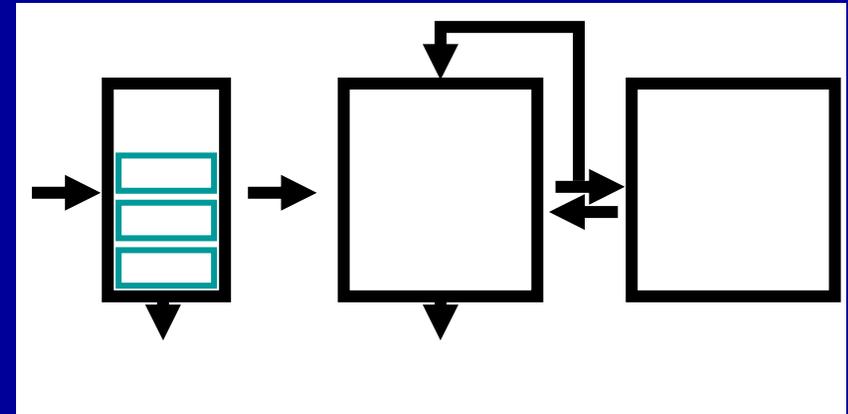
# Evaluating the Atkinson-Shiffrin model



- Evidence against a simple rehearsal-based transfer of information from STM to LTM
  - Craik and Lockhart, 1972
- Evidence against a unitary short-term store
  - Warrington and Shallice, 1972

# Craik-Lockhart levels-of-processing model

SPEECH	each
BRUSH	lush
CHEEK	teak
FLOUR	sour
HONEY	funny
GLOVE	shove
...	...

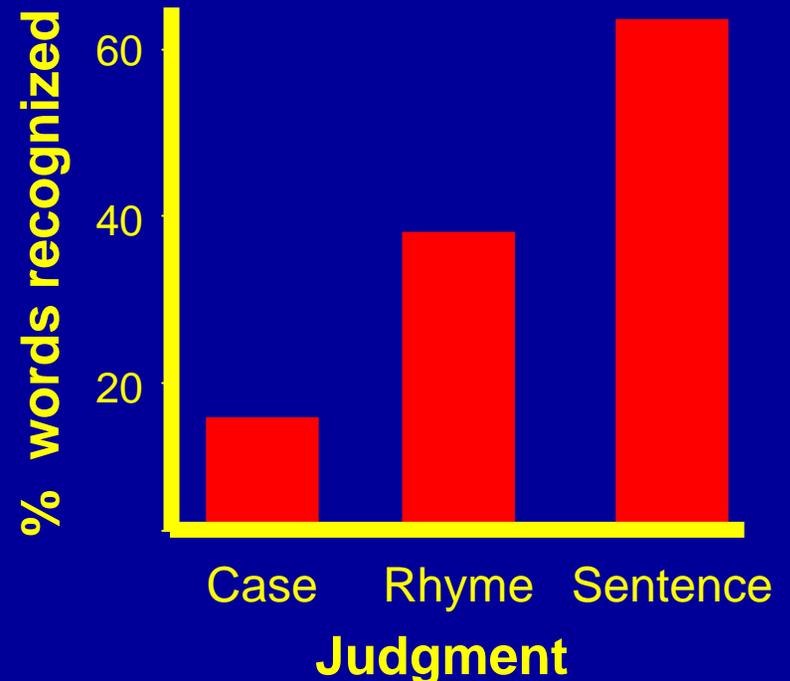


Is the word in capital letters?

Does the word rhyme with \_\_\_\_\_?

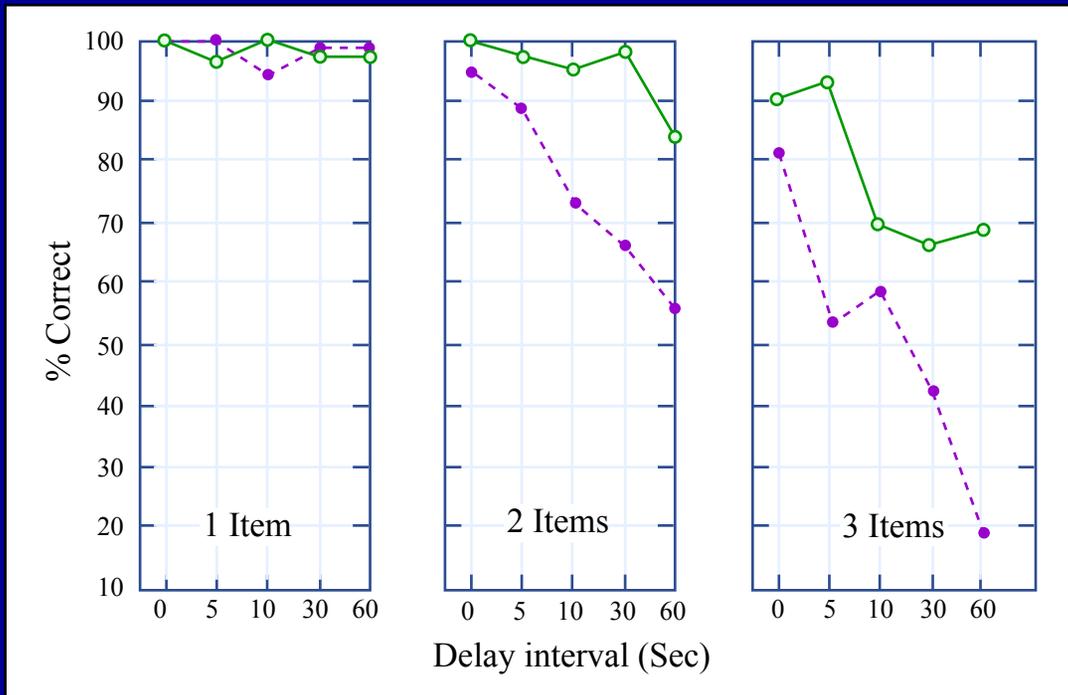
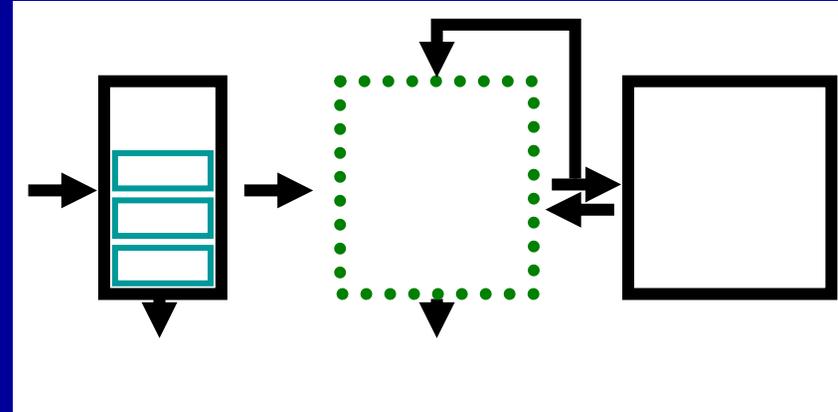
Would the word fit the sentence:

“He met a \_\_\_\_\_ in the street”?



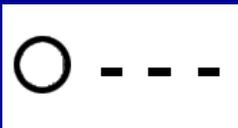
# Evidence from Patient K.F. against a unitary STS

Span	1-3 letter stimulus presented at 1Hz	0,5,10,15 sec distraction
Visual		
Auditory		



Presentation

Visual



Auditory



- Two primary assumptions of the Atkinson-Shiffrin model are incorrect:
  - Short-term store is not a unitary store
  - Simple rehearsal cannot fully account for transfer of information from STM to LTM
- Evidence against the modal model led Baddeley and Hitch to propose a multi-component model of temporary memory capacities called “working memory”
- STM:
  - Memorize 773-562-5519 and then repeat it in the same order
- Working memory
  - Memorize 773-562-5519, sort it and repeat it from the largest to the smallest number

# Baddeley-Hitch model

Working memory is the ability to maintain and manipulate information online to guide a goal-directed behavior.

**Phonological Loop**



**Central Executive**



**Visuo-Spatial Sketchpad**

a modality free control system of limited attentional capacity that is responsible for the manipulation of information within working memory and for controlling two subsidiary storage systems

Baddeley-Hitch model is process (maintenance vs manipulation) and material (visual vs. verbal) specific

# Visuospatial sketchpad and phonological loop are distinct

**Phonological Loop**



**Central Executive**



**Visuo-Spatial Sketchpad**

# Visuospatial sketchpad and phonological loop are distinct

## Dual-task evidence

Visual	Verbal
	RG
	RGX
	RGXD

## Neuropsychological evidence

K.F. has a normal visual span, but severely impaired verbal span

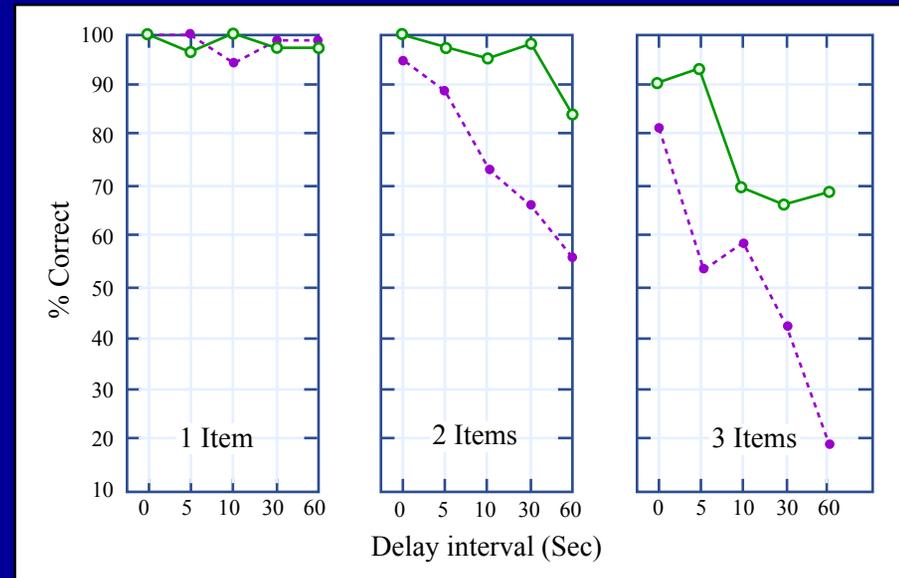
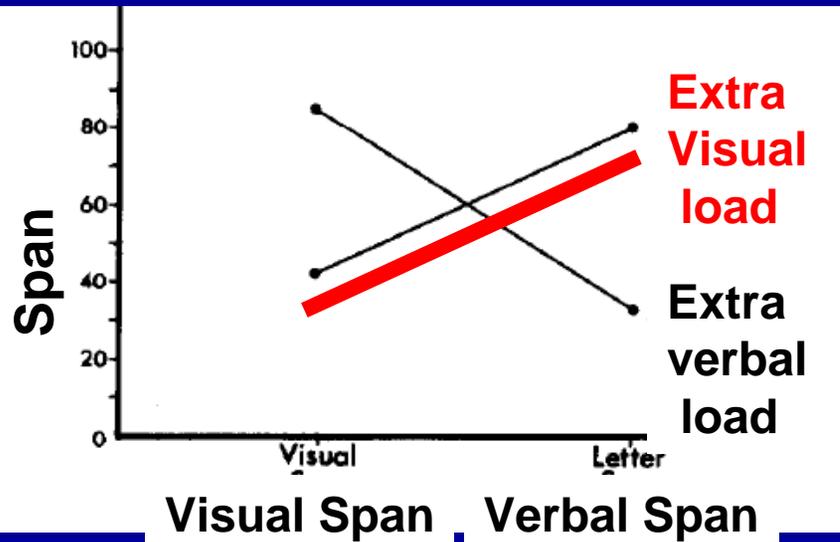


Figure by MIT OpenCourseWare.

Warrington et. al., 1972

# Evidence for the phonological loop

**Phonological Loop**



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**Visuo-Spatial Sketchpad**

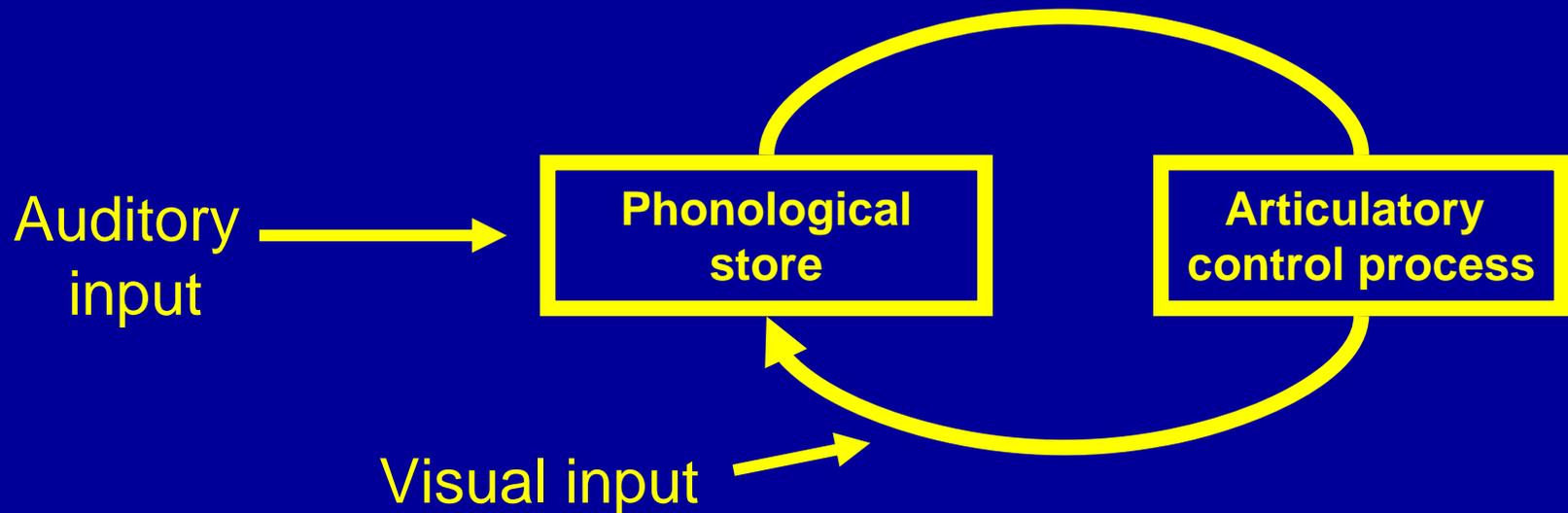
# Phonological loop

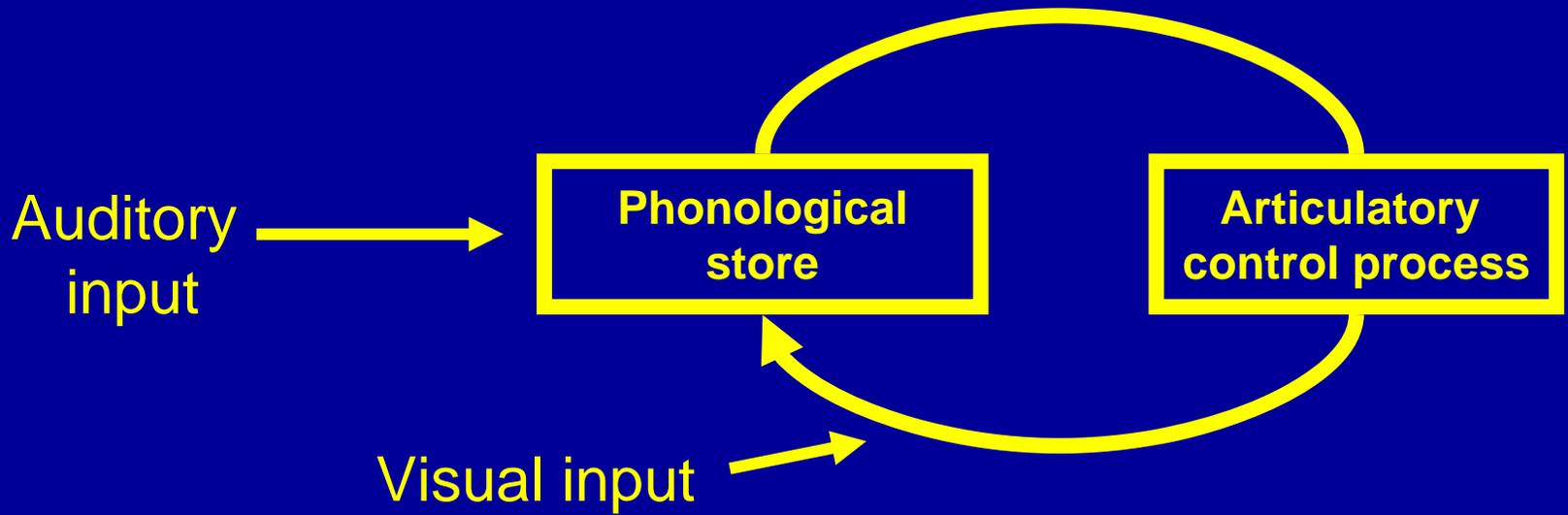
## Phonological store

holds phonological memory for a few seconds before it fades

## Articulatory control process

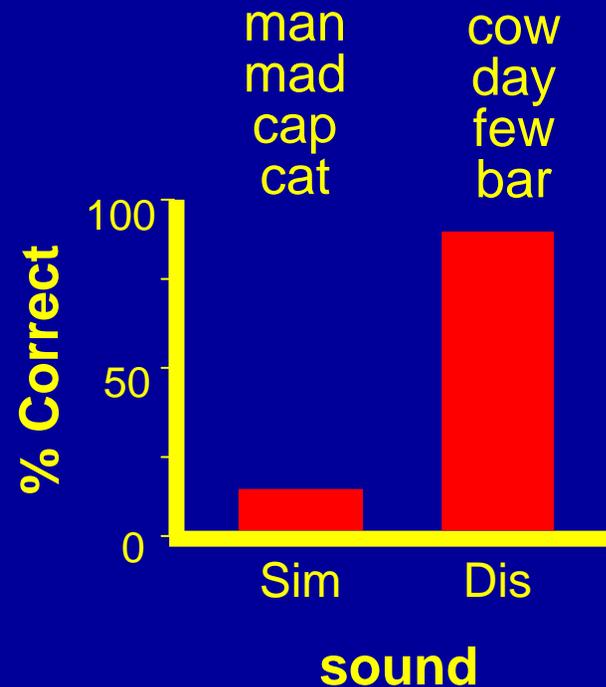
refreshes the memory trace by retrieval and re-articulation

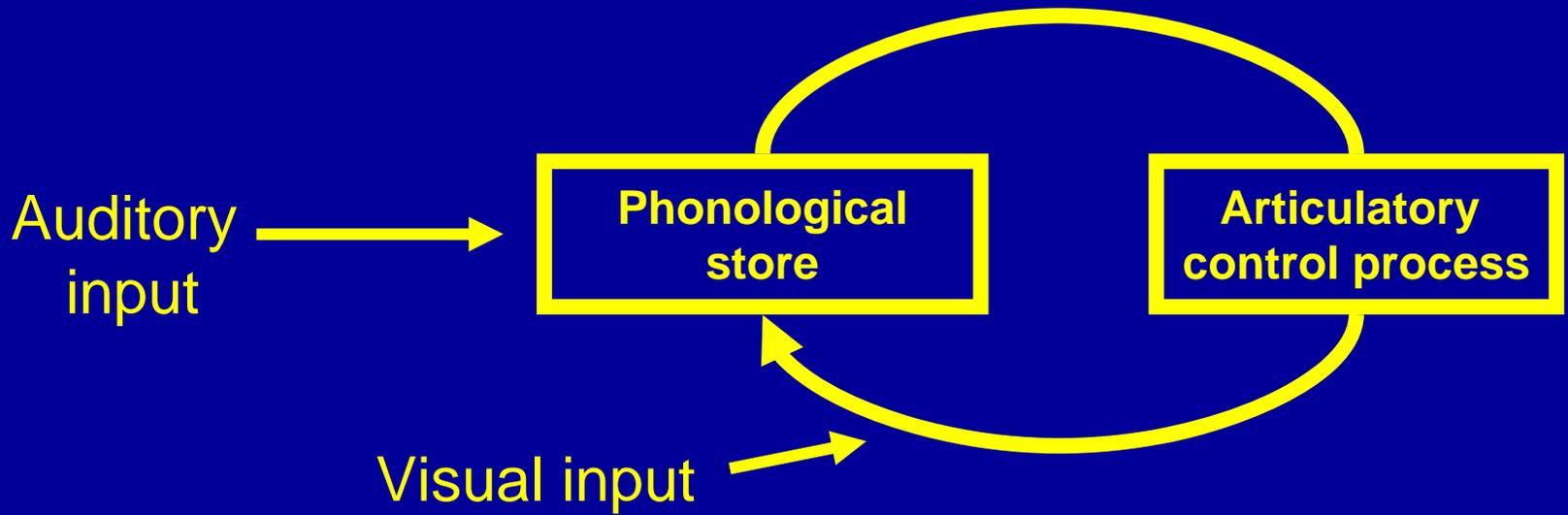




## Phonological store

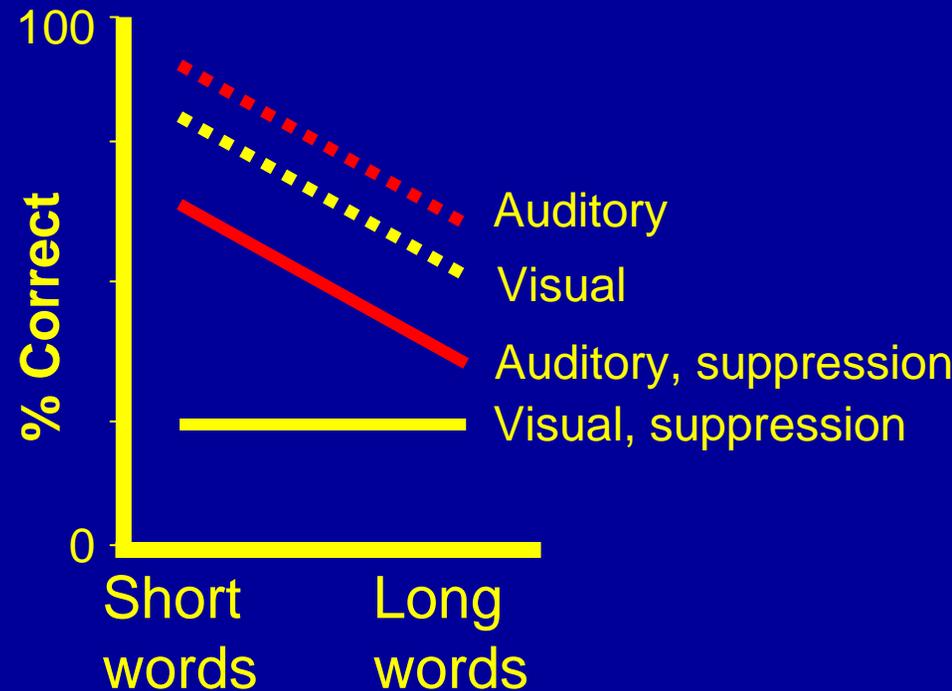
Evidence from:  
Phonological similarity effect





## Articulatory control process

Evidence from:  
 Word length effect  
 Articulatory suppression effect



# Visuo-spatial sketchpad

**Phonological Loop**



**Central Executive**



**Visuo-Spatial Sketchpad**

# Visuo-spatial sketchpad

## Visual component

holds visual form and color information

## Spatial component

holds spatial and movement information

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# Central Executive

**Phonological Loop**



**Central Executive**



**Visuo-Spatial Sketchpad**

**Phonological Loop**



**Central Executive**



**Visuo-Spatial Sketchpad**

Major functions of the central executive include:

- Switching attention between tasks
- Planning sub-tasks to achieve a goal
- Selective attention and inhibition
- Updating and checking contents of working memory

# Evidence for central executive

## Primary visual-spatial Material

Text removed due to copyright restrictions.

Small sample:

"In the starting square put an A.  
In the next square to the right put a B.  
In the next square down put a C. ..."

	A			

## Secondary tasks:

Spatial interference  
finger tapping

Verbal interference  
say "go ... go ... go"

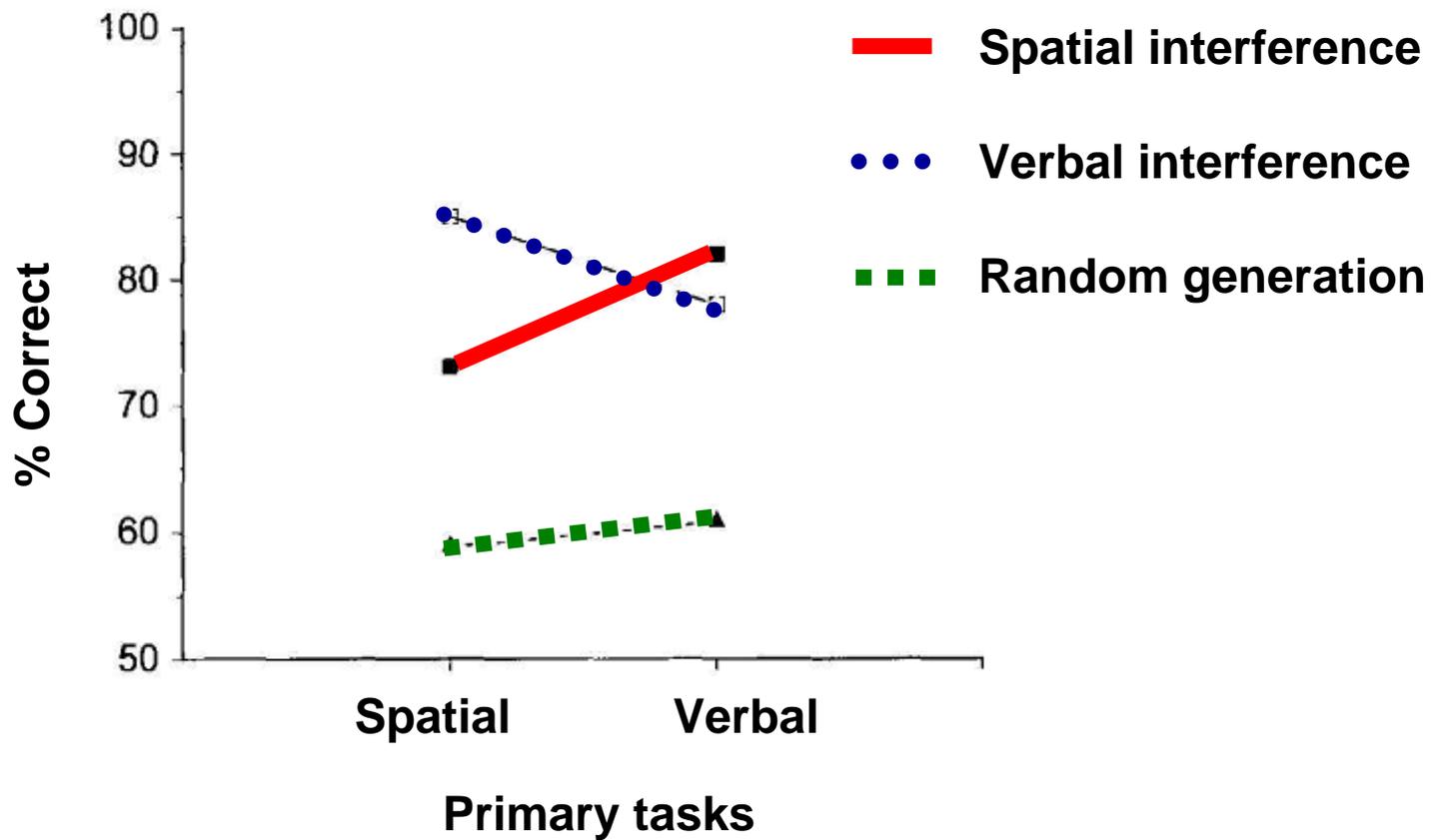
Central interference  
random number generation

## Primary verbal Material

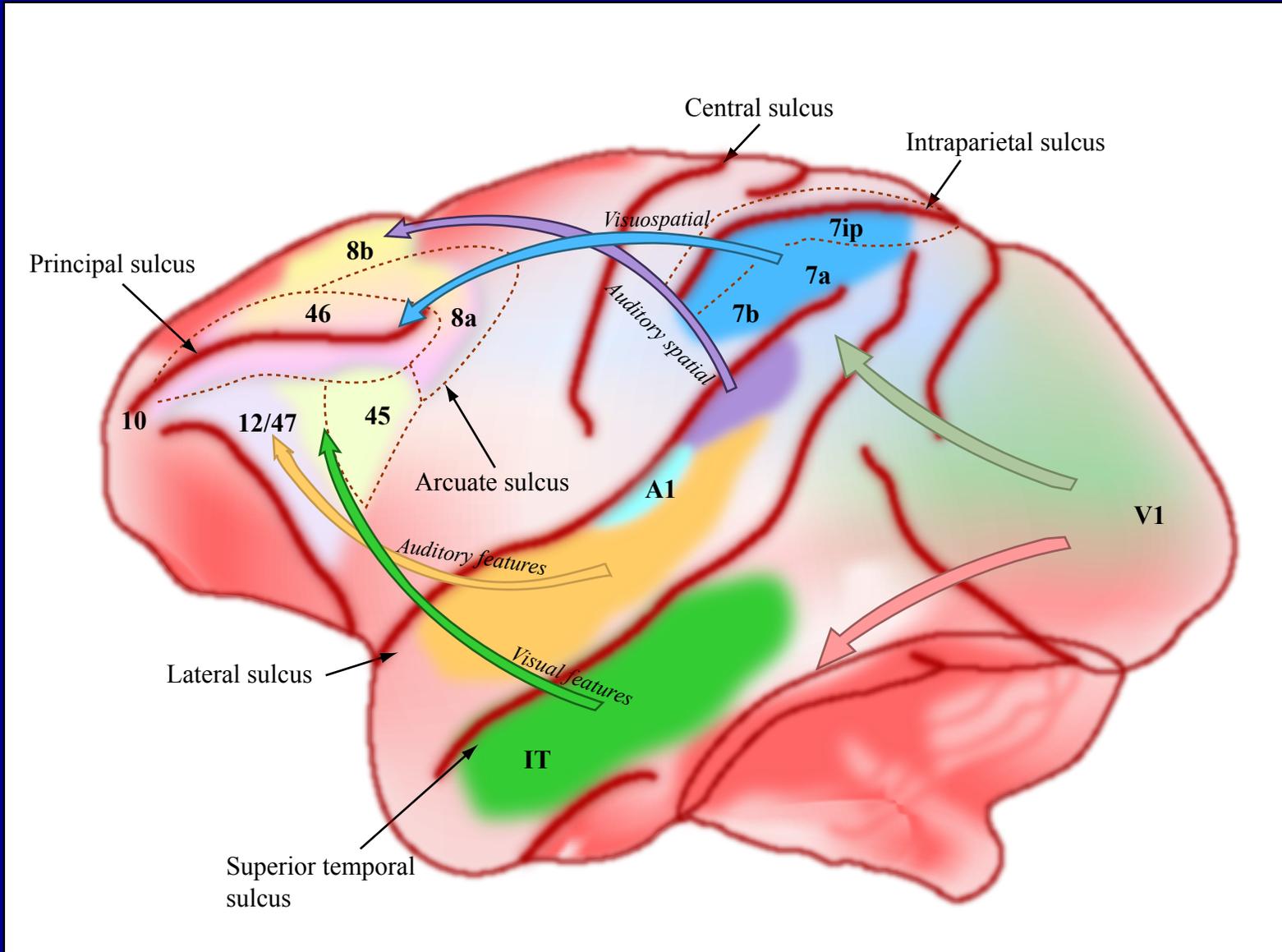
Text removed due to copyright restrictions.

Small sample:

"In the starting square put an A.  
In the next square to the right put a B.  
In the next square down put a C. ..."



# Anatomical localization of central executive



# Student Report

Thank you!