

Sensory, short- term, and working memory

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Cartoon involving long- and short-term memory.

Paymon Hosseini

10/10/2007

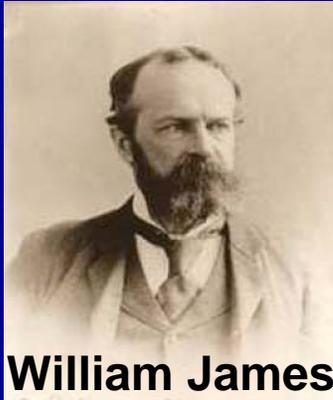
Outline

- 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



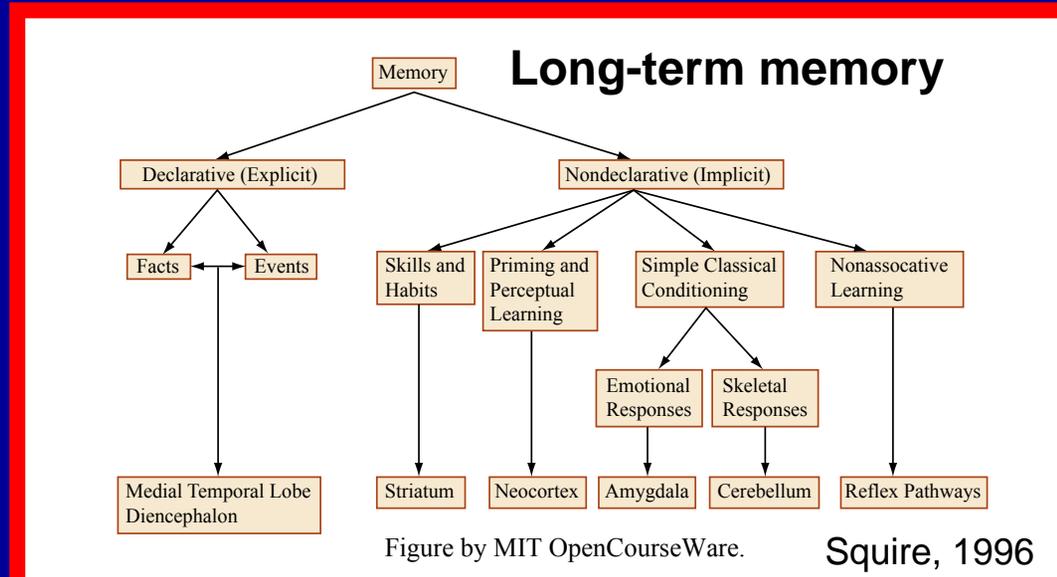
William James

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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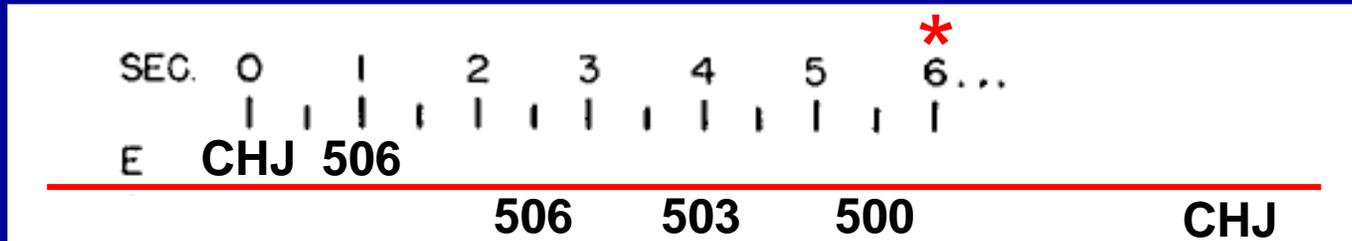
Span: 7 ± 2 “chunks”

8 7 3 2 5 9 4 3 5 6

873 259 4356

Capacity of STM is limited

Duration

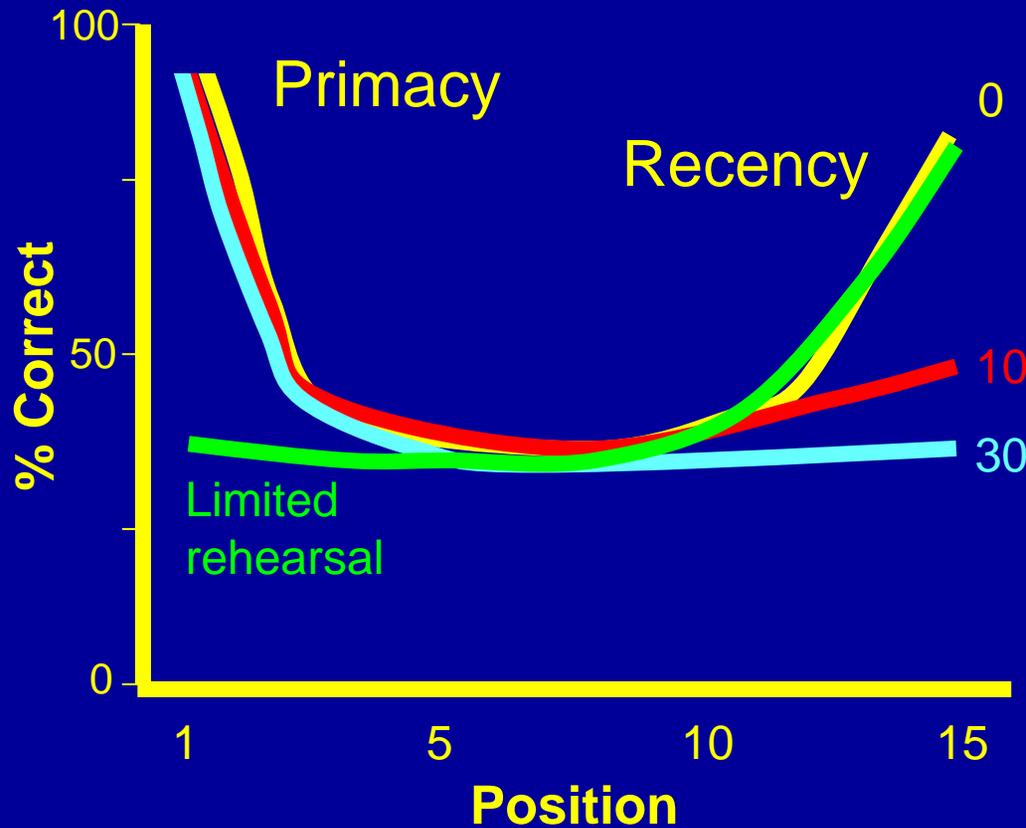


Without attention and rehearsal, information is lost rapidly from STM

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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

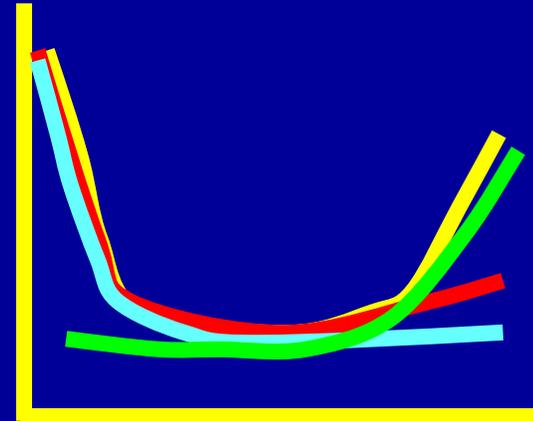
7 ± 2 chunks

- Short duration

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- Lost quickly without attention and rehearsal

- Rehearsal facilitates transfer of information from STM to LTM



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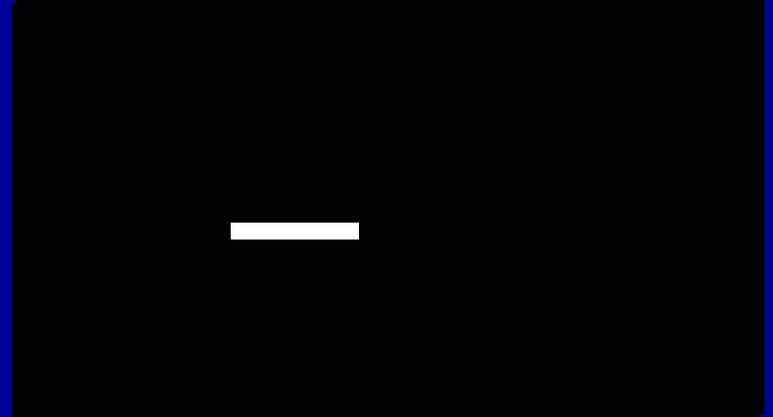
Given larger and larger matrices of letters, the ability to recall these letters maxes out at about 4.5 (averaged over 5 test participants).

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

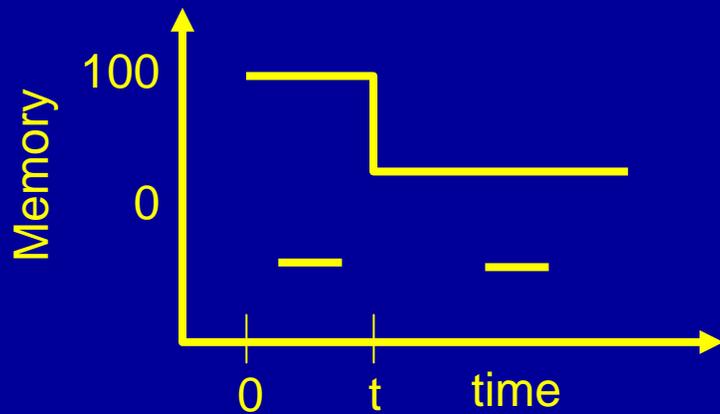


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Performance does not drop to chance because of contributions from STM, which operates on a longer time scale than iconic memory

Duration of iconic memory is roughly 200 ms

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Temporary memory systems summary

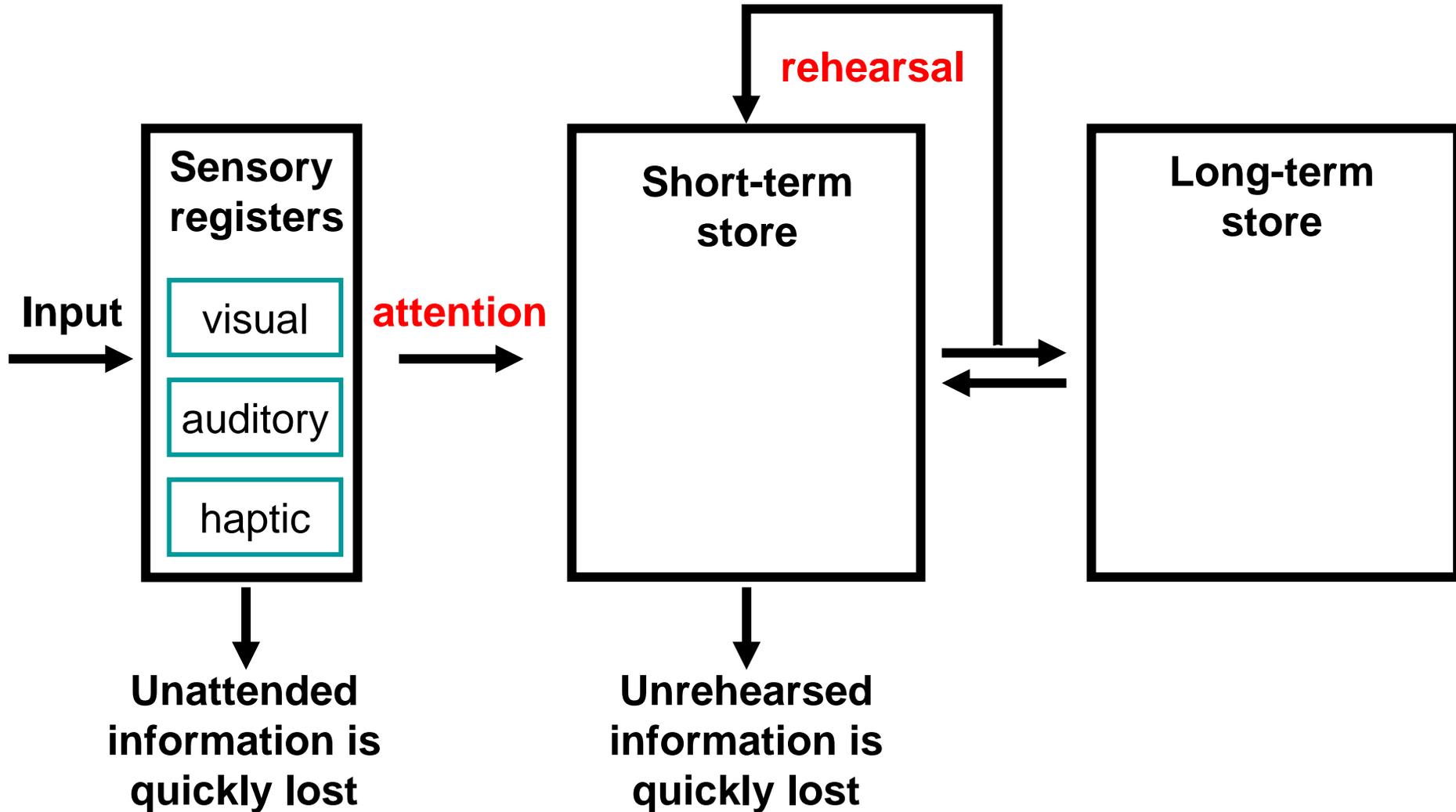
Sensory memory	Short-term memory	LTM
<ul style="list-style-type: none">• Large capacity• Modality-specific stores• Very brief duration• Lost rapidly w/o attention	<ul style="list-style-type: none">• Limited capacity• Short duration• Lost without attention and rehearsal• Rehearsal facilitates transfer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

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

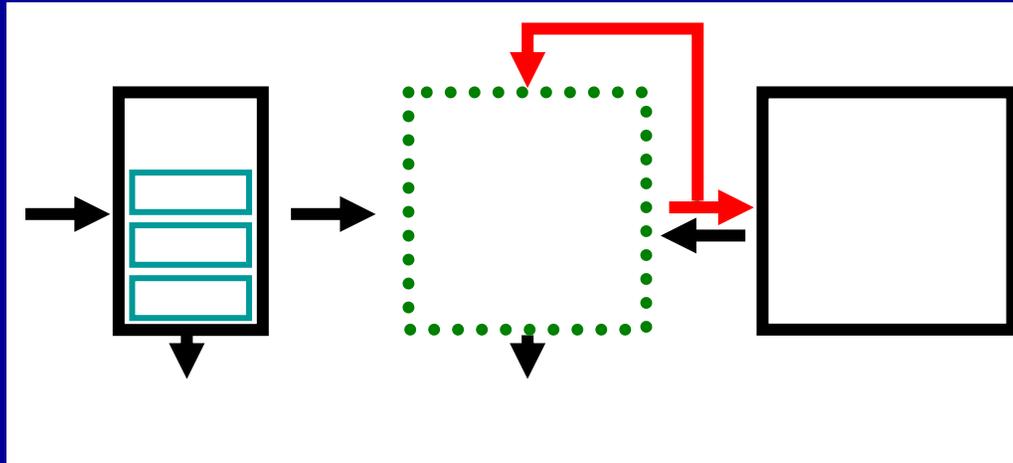
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Atkinson-Shiffrin modal model



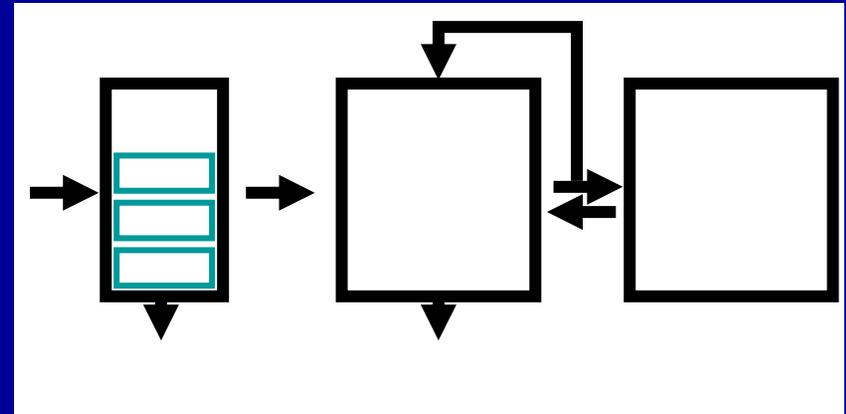
Evaluating the Atkinson-Shiffrin model



- 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
...	...

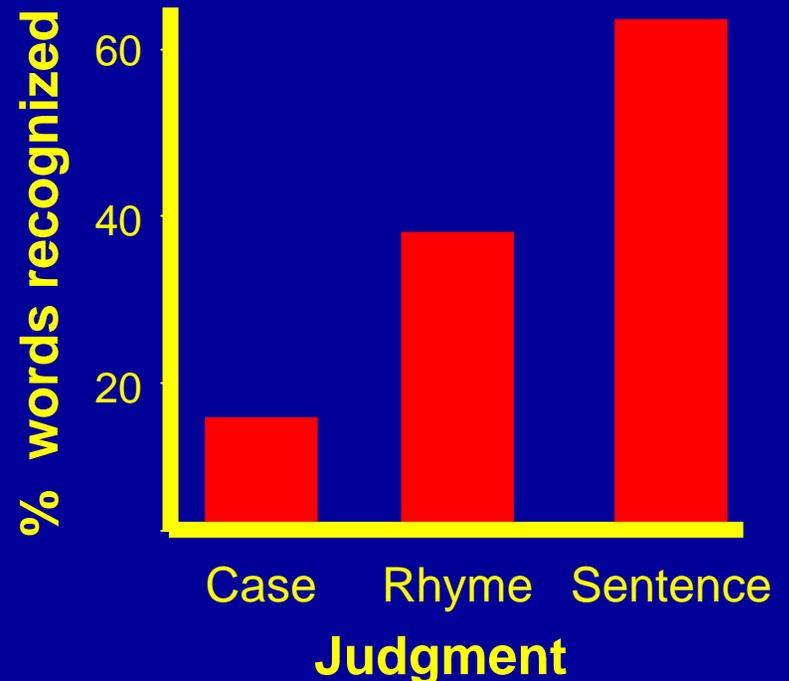


Is the word in capital letters?

Does the word rhyme with _____?

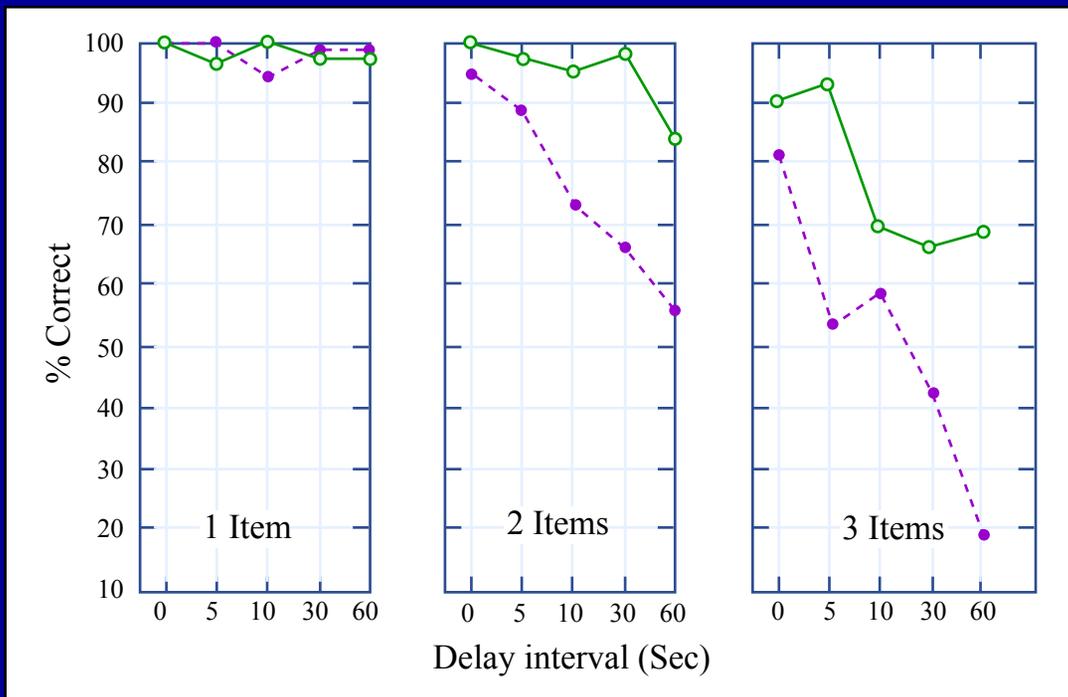
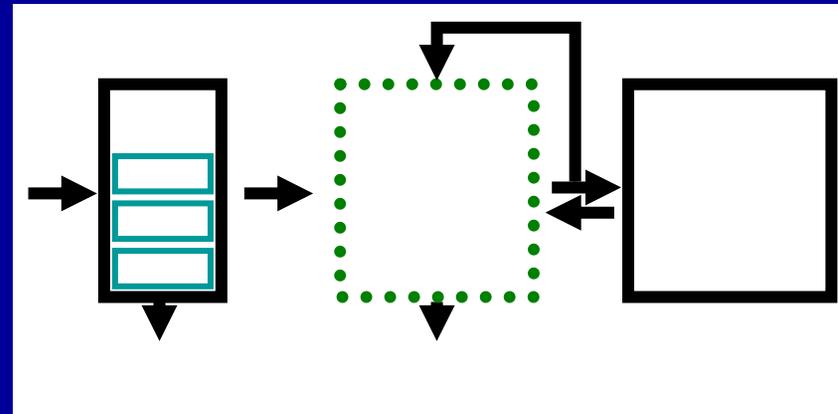
Would the word fit the sentence:

“He met a _____ in the street”?



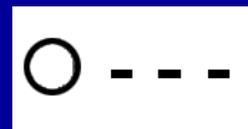
Evidence from Patient K.F. against a unitary STS

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

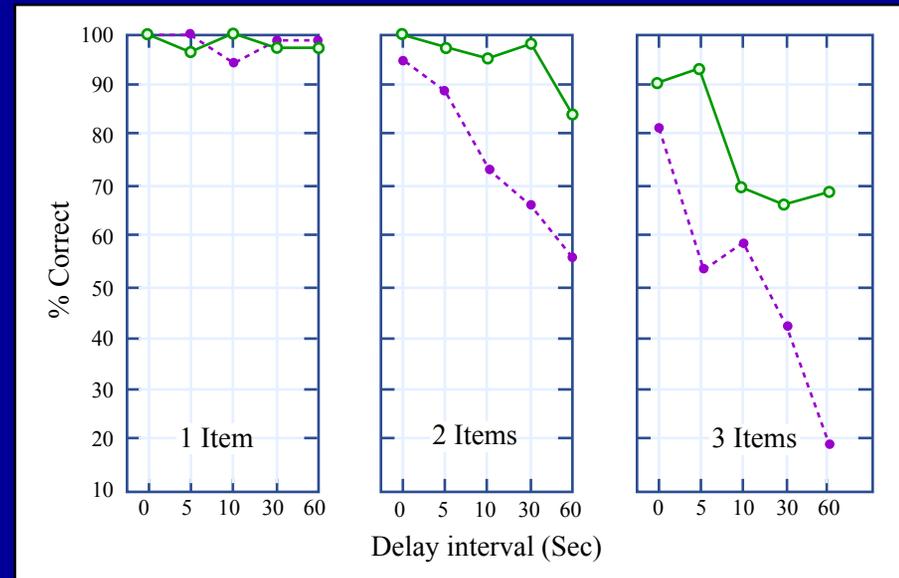
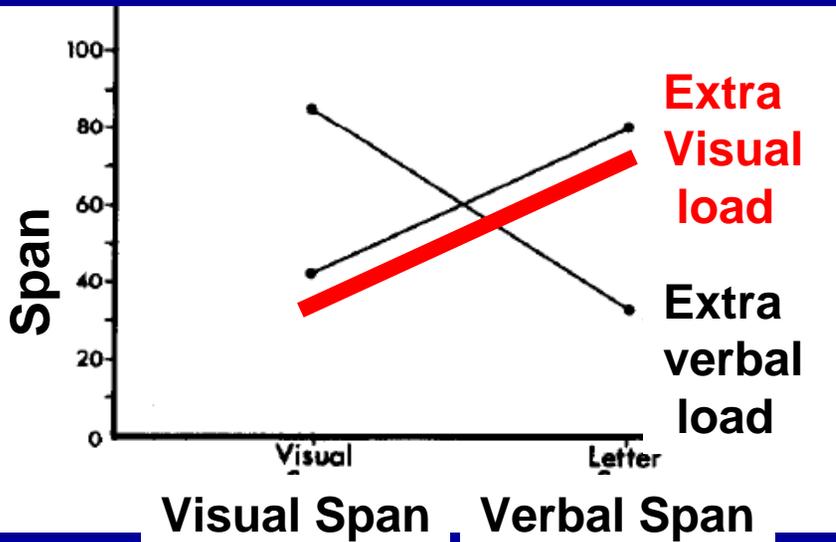
Visuospatial sketchpad and phonological loop are distinct

Dual-task evidence

Visual	Verbal
	RG
	RGX
	RGXD

Neuropsychological evidence

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



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Figure by MIT OpenCourseWare.

Logie et. al., 1990

Warrington et. al., 1972

Evidence for the phonological loop

Phonological Loop



Central Executive



Visuo-Spatial Sketchpad

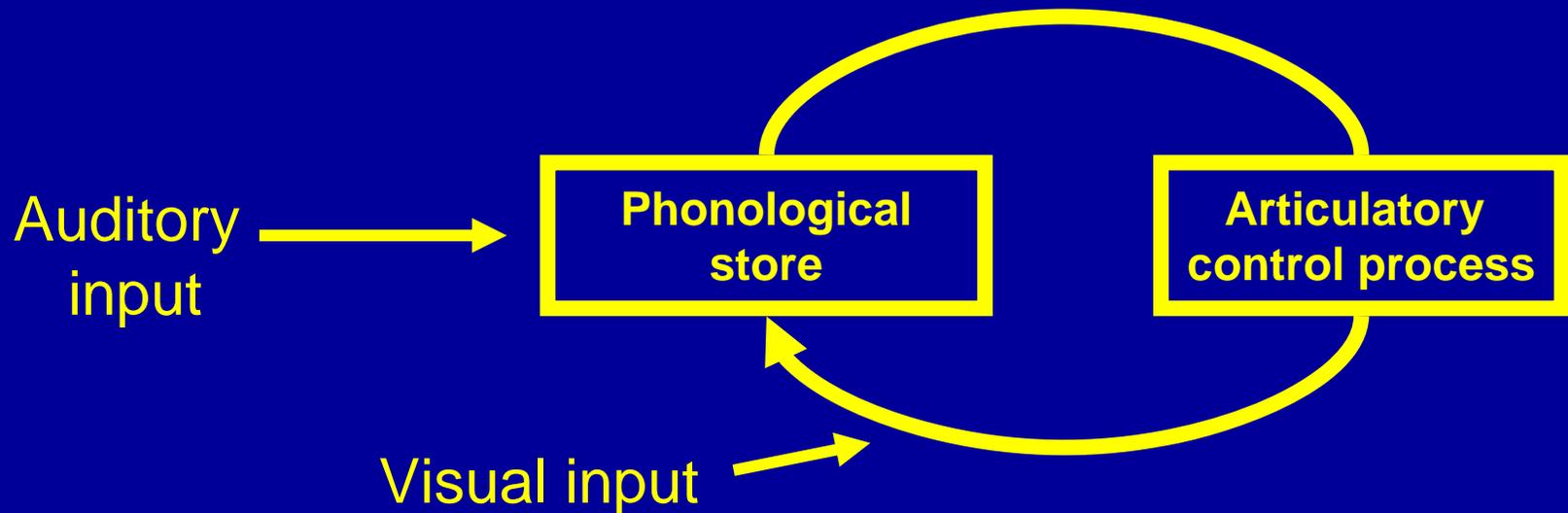
Phonological loop

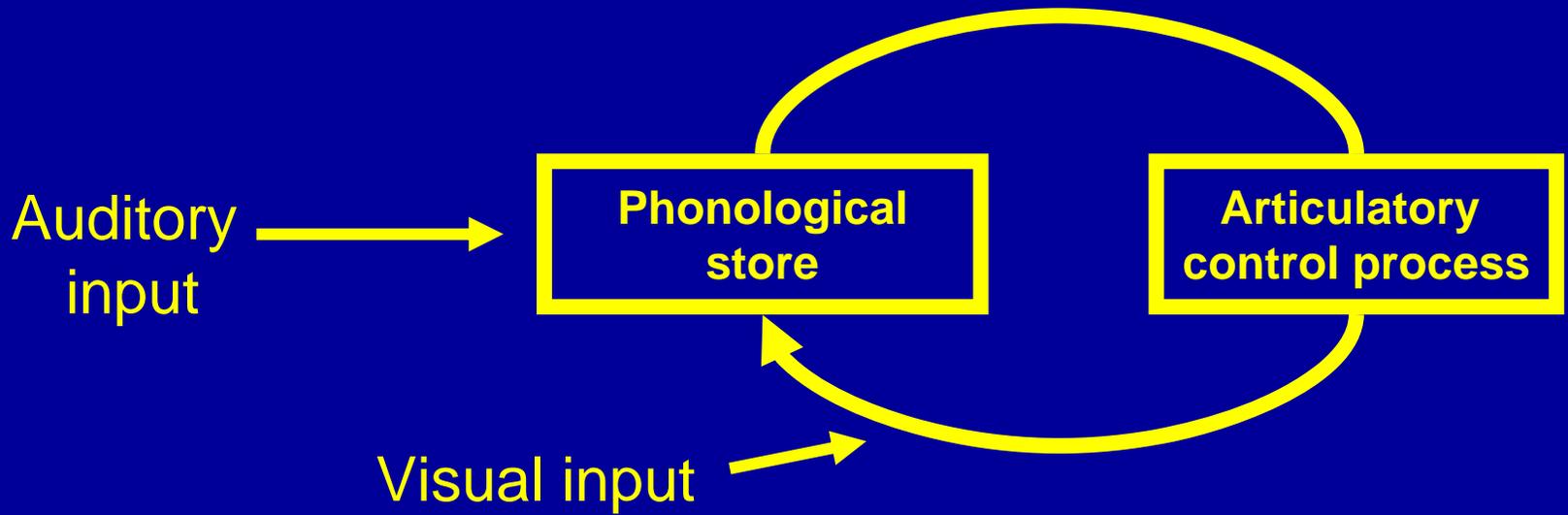
Phonological store

holds phonological memory for a few seconds before it fades

Articulatory control process

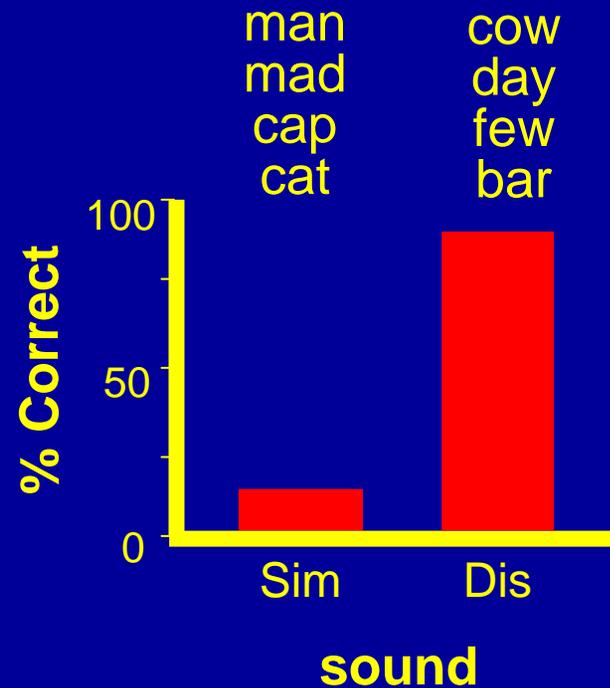
refreshes the memory trace by retrieval and re-articulation

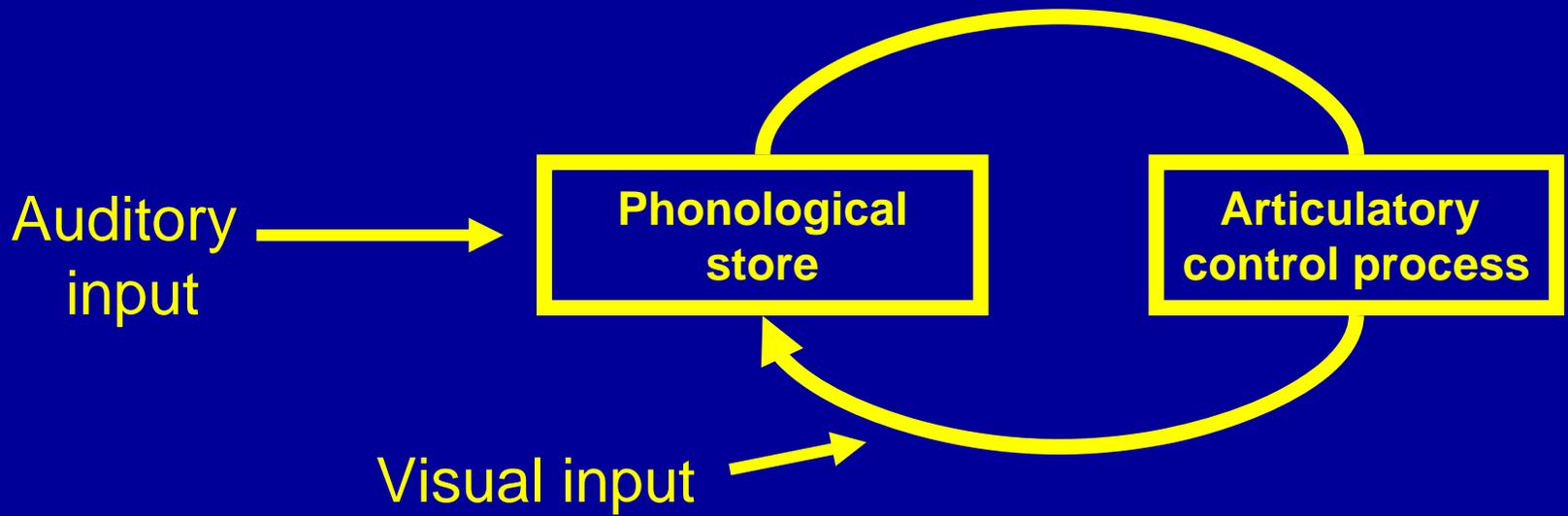




Phonological store

Evidence from:
Phonological similarity effect



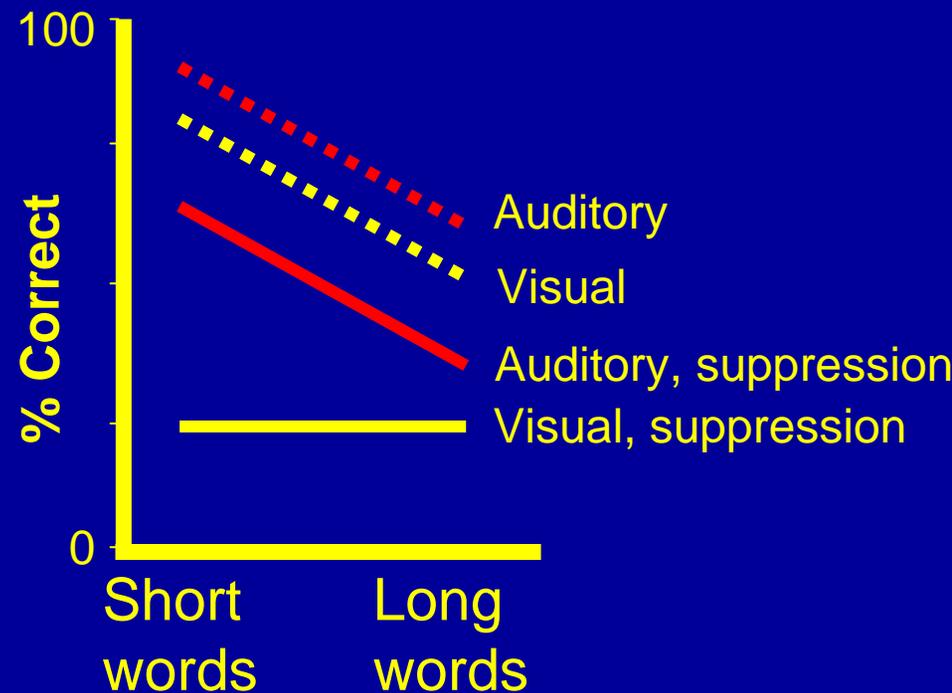


Articulatory control process

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

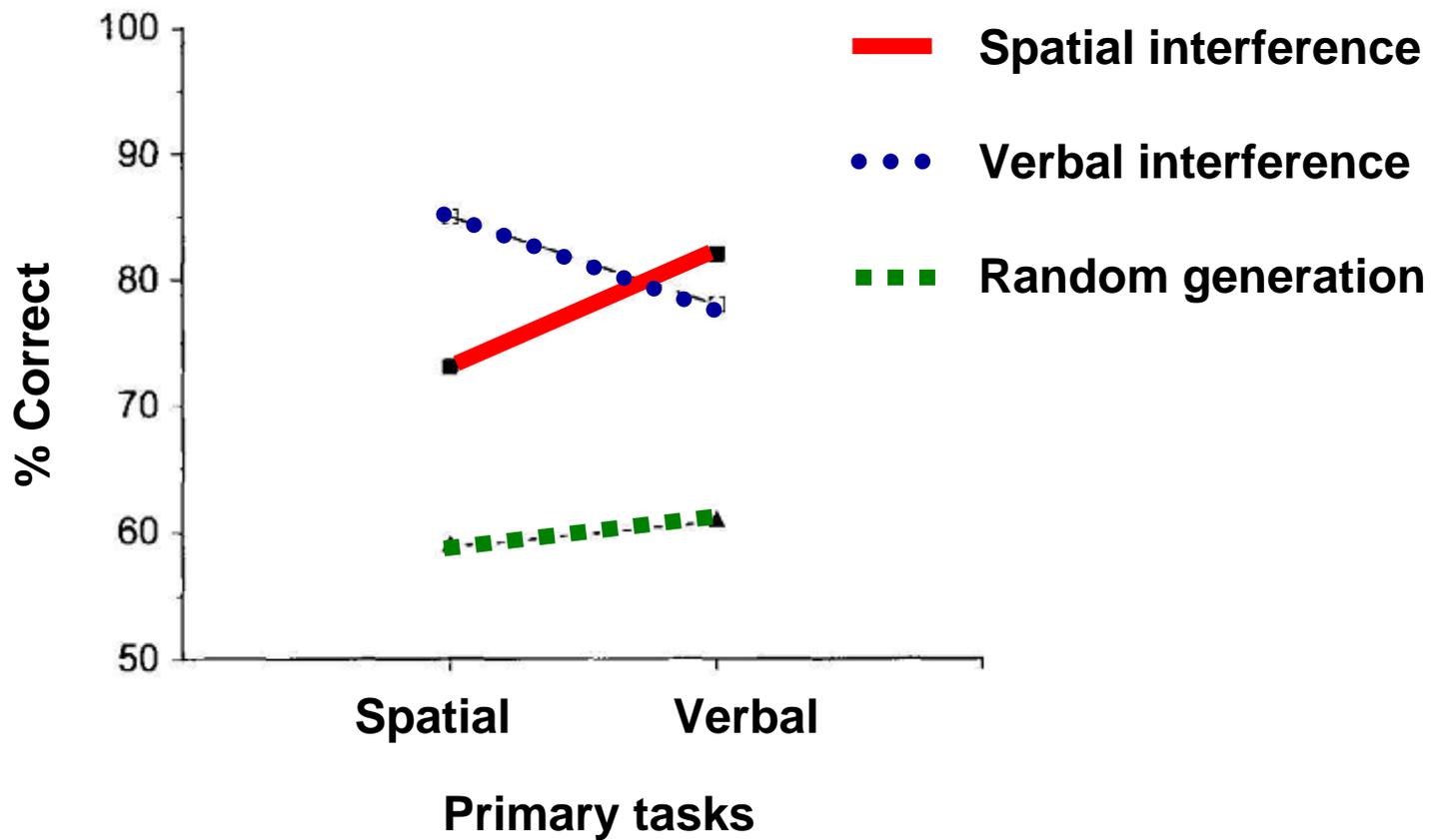
random number generation

Primary verbal Material

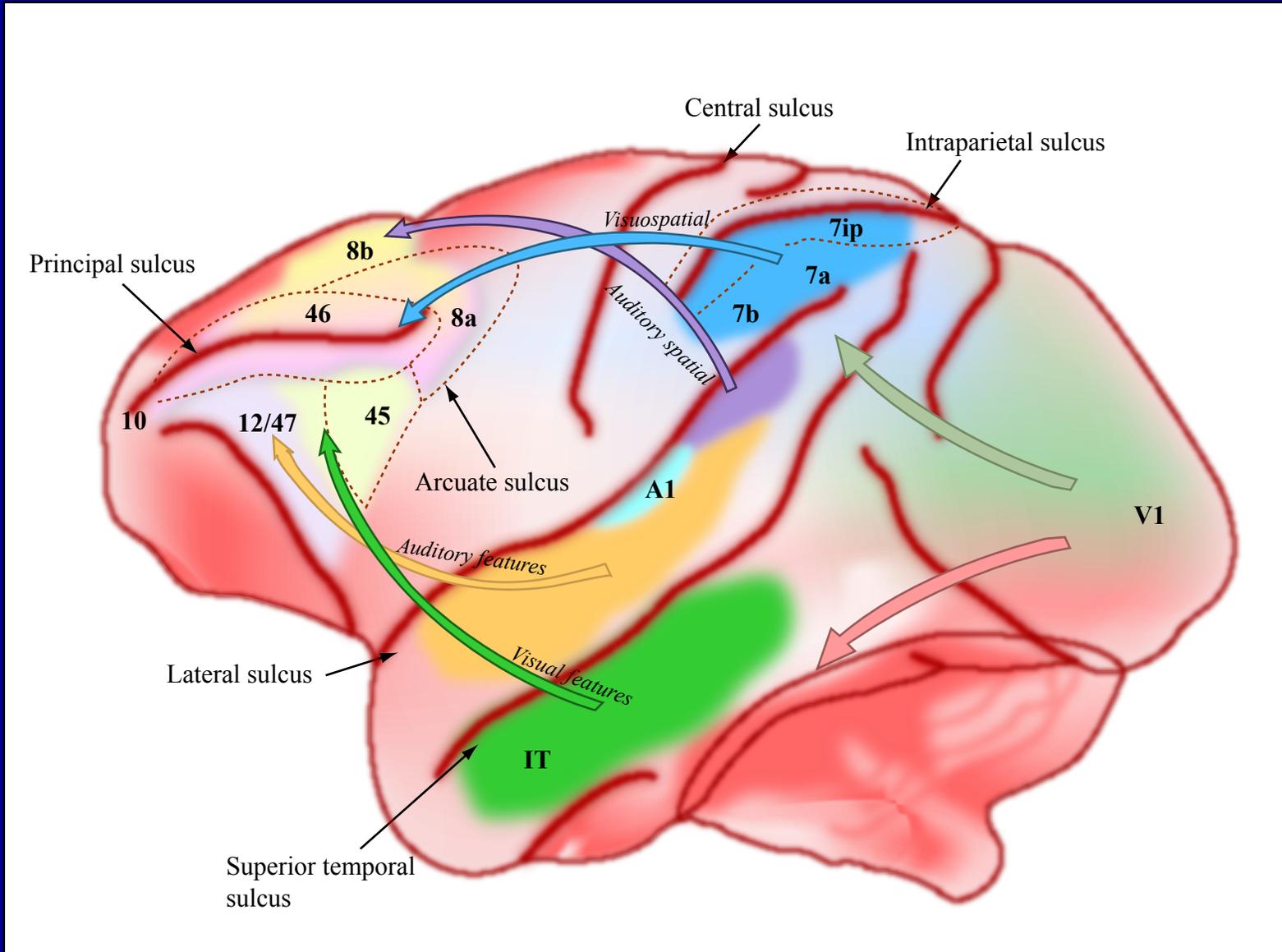
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Small sample:

"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!