PSYC 10004-6 – FOUNDATIONS OF PSYCHOLOGY
Introduction to Cognitive Psychology

Lecture 6 – Short-term Memory

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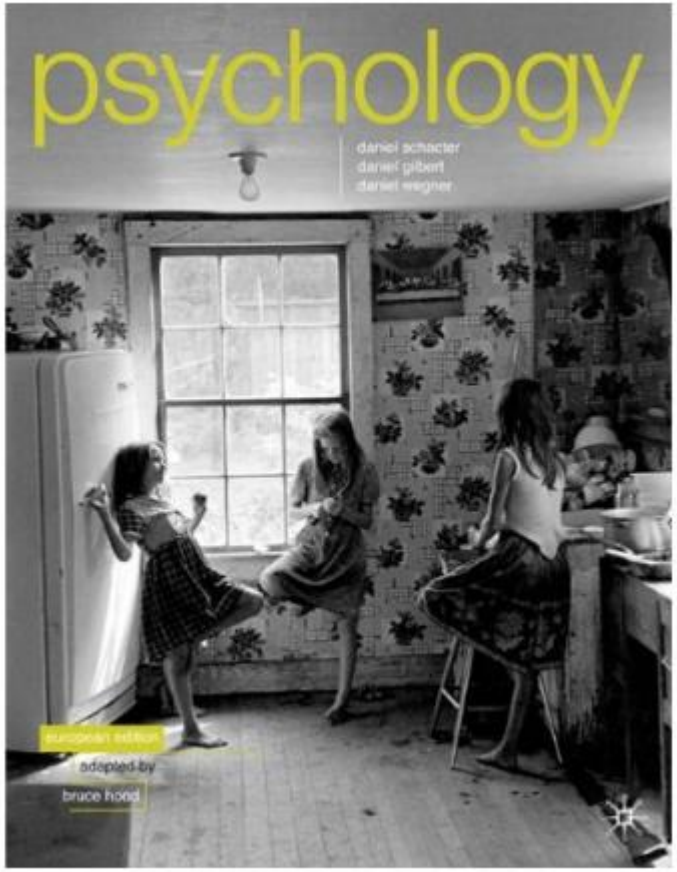
Additional reading:

- Schacter, Gilbert, Wegner & Hood (2011), Psychology. New York: Worth
  - Chapter 5 (“Memory“)
- Also: any recent textbook on Cognitive Psychology, such as Ashcraft & Radvansky (2010), Chapter 5 (Short-term working memory)



Different types of memory?

- Intuitively, most individuals feel that long-lasting memories ("what's the capital of Greece?") are fundamentally different from memories storied for very brief durations ("Here is the door code to get out of the building: 4872")

- Short-term (or primary) memory - STM
  - holds information only very briefly
  - has severely limited capacity

- Long-term (or secondary) memory - LTM
  - holds information over long periods
  - has potentially unlimited capacity

Aims of lecture

- what's the difference between short- and long-term memory?
- how can STM be measured? What is its capacity? How many items can be held? For how long?
- can STM be selectively impaired in individuals with acquired brain damage while LTM is intact, and vice versa?
- what is STM good for?
- Baddeley's "working memory" model

What is STM good for?

- many complex cognitive tasks require short-term storage (or buffering) of information - combining
  - sensorial information from the environment
  - long-term memory representations (internal)

- examples:
  - adding numbers: 3 + 4 – (9 – 5) + 12 = ?

- language comprehension: “David Cameron thought that he could win the election” – how do we know what “he” referred to? Presumably, “David Cameron” was temporarily “buffered” in STM…

Capacity of STM

"Digit span task":

http://cognitivefun.net/test/9

Miller (1956) - The magic number seven, plus or minus two

"My problem is that I have been persecuted by an integer. For seven years this number has followed me around, has intruded in my most private data, and has assaulted me from the pages of our most public journals. This number assumes a variety of disguises, being sometimes a little larger and sometimes a little smaller than usual, but never changing so much as to be unrecognizable. The persistence with which this number plagues me is far more than a random accident. […] Either there really is something unusual about the number or else I am suffering from delusions of persecution."

Miller (1956) - The magic number seven, plus or minus two

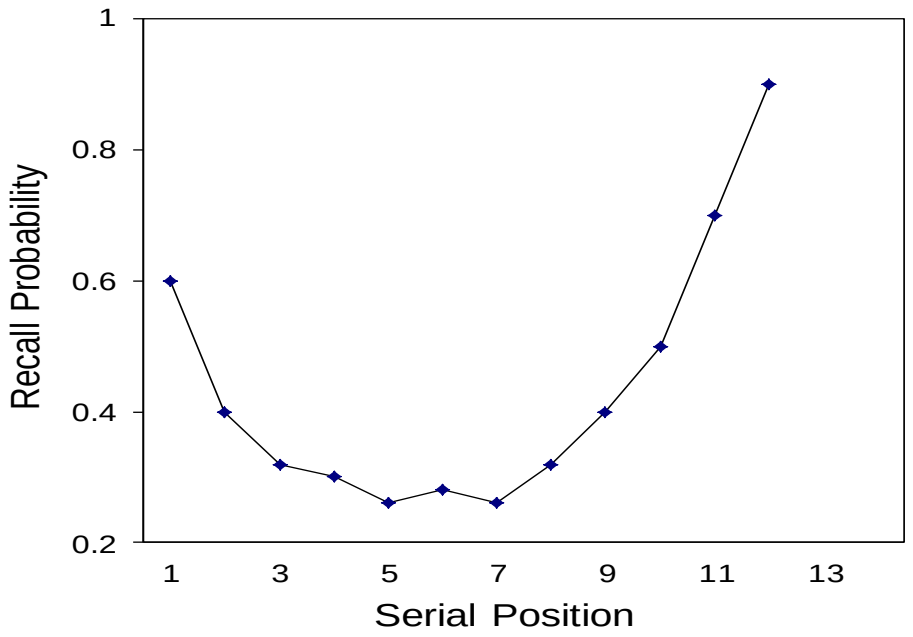
- across large variety of tasks, individuals can hold ~7 items simultaneously in STM
- capacity largely independent of nature of items:
  - digits: 9 2 4 7 3 8 1
  - letters: T M F J R L B
  - words: HAT CUP BOOT LOG TEA ROOM WINE

- but, capacity is less than seven for items that don't mean anything:
  - nonwords: BLIC CIP TUL SIL FLAR PRI KOM

- short-term memory performance typically operates on representations which are permanently stored in our minds

“Superspan lists” – less-than-perfect performance

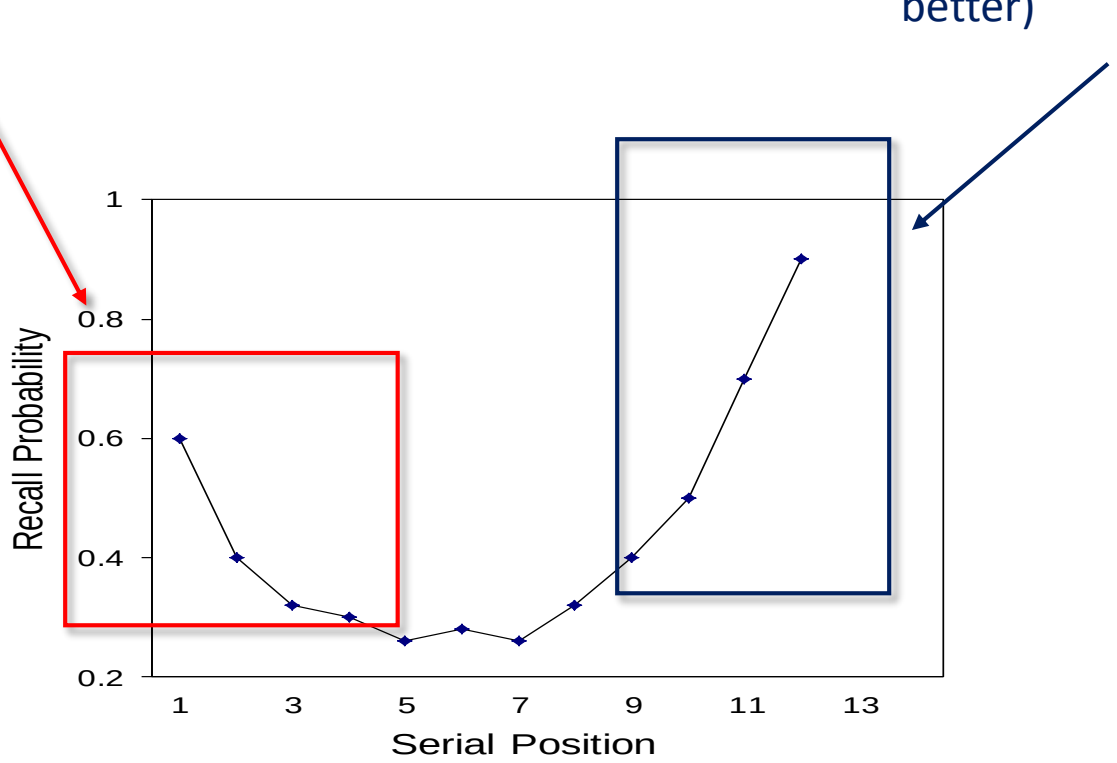
- present lists of items longer than max. capacity of STM (~7)
- free recall task: recall the list of items, in any order
- across many trials, plot average recall probability (y-axis) dependent on list position (x-axis). E.g., for list of 12 letters:



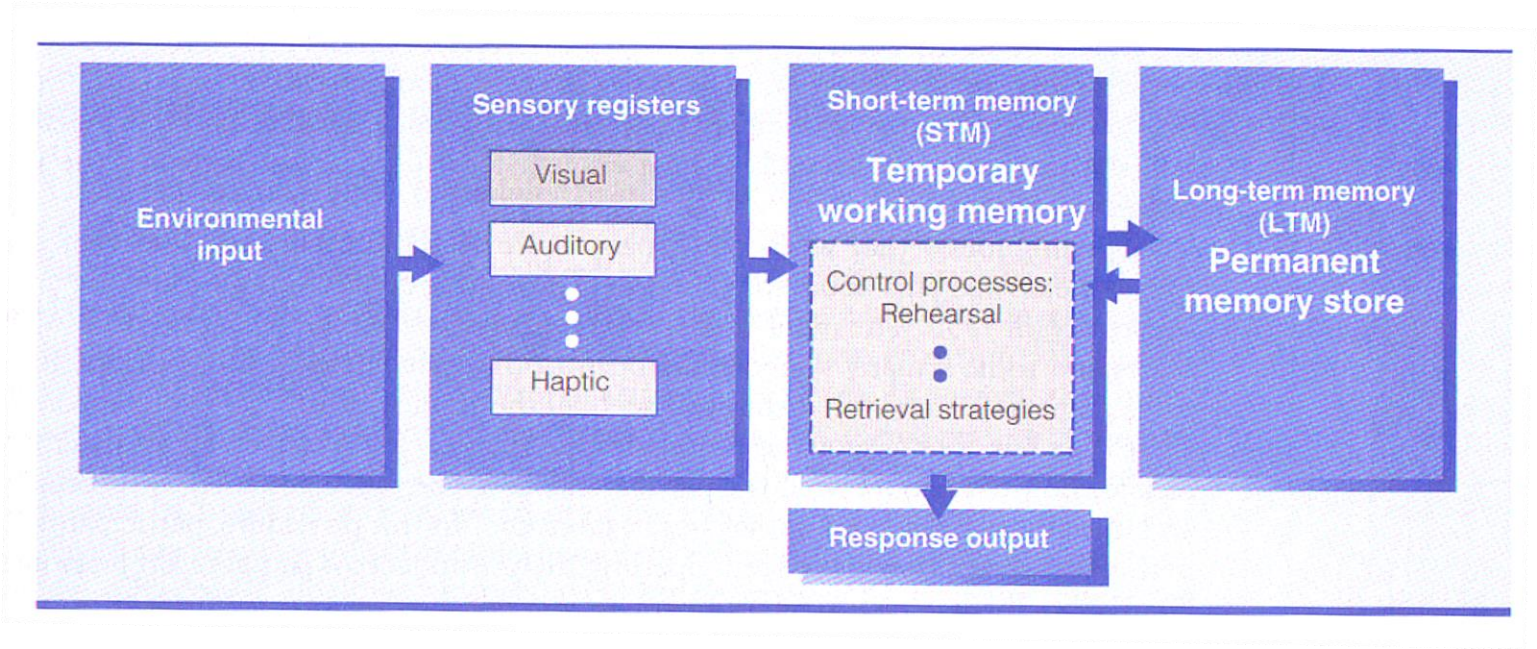
“Serial position curve”

Primacy effect - assumed to reflect contribution of LTM (earlier items undergo more or better rehearsal)

Recency effect - assumed to reflect contribution of STM (items that are still active in short-term store are recalled better)



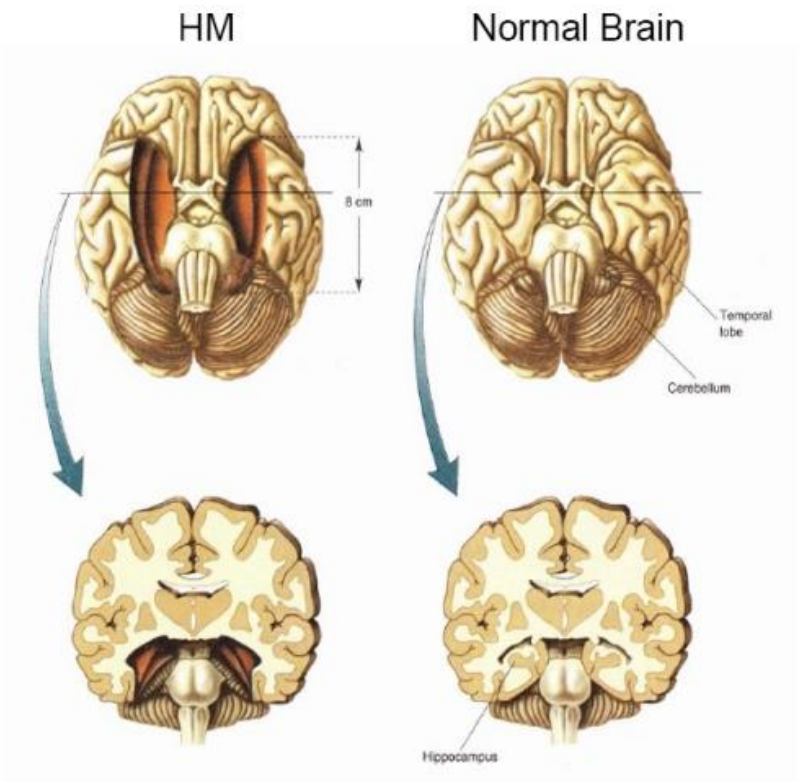
Modal model of STM (e.g., Atkinson & Shiffrin, 1968)



- STM has limited capacity of about 7 items
- items must pass through STM in order to enter LTM
- the longer an item held in STM, the more likely to be transferred to LTM
- info is held in STM by means of *rehearsal*

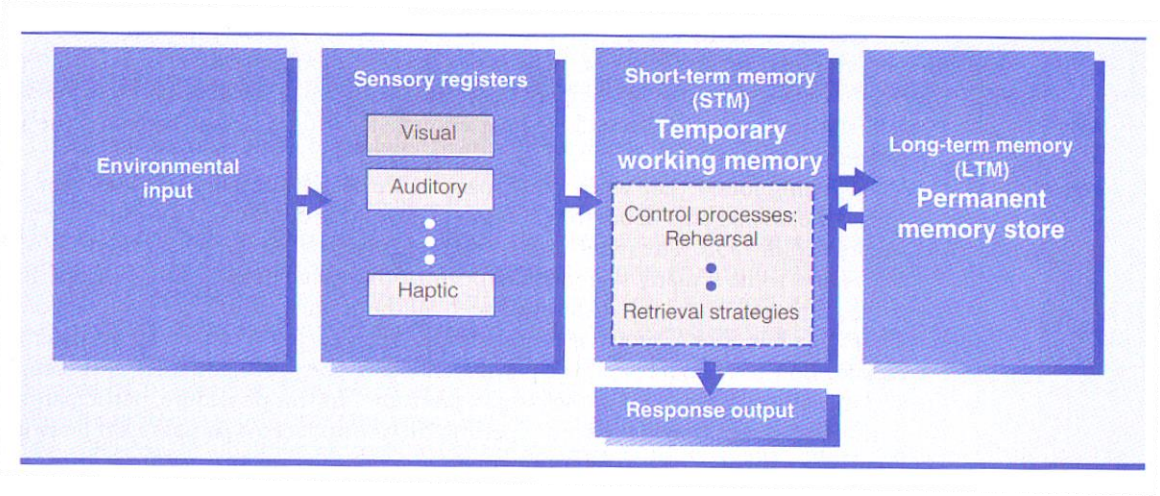
Double dissociation between STM and LTM?

- Cases of normal STM but impaired LTM? Yes!
- E.g., Milner (1966): the case of HM
- suffered from intractable epilepsy
- part of his temporal lobes surgically removed, including hippocampus
- showed defective LTM learning: “anterograde amnesia” – inability to acquire new information post surgery
- but, had normal STM!
- See extensive case review on Wikipedia: http://en.wikipedia.org/wiki/Henry_Molaison



Double dissociation between STM and LTM?

- Cases of normal LTM but impaired STM? Yes!
- Shallice & Warrington (1970): the case of KF – brain damage following motorbike accident
- LTM performance in normal range (learning of word pairs, lists of words, etc.)
- STM dramatically impaired: usual digit span of 7±2 reduced to max. 2 (!)
- neuropsychological evidence is compatible with possibility that STM and LTM are separately coded in the brain



Baddeley & Hitch (1974) - Effects of concurrent load

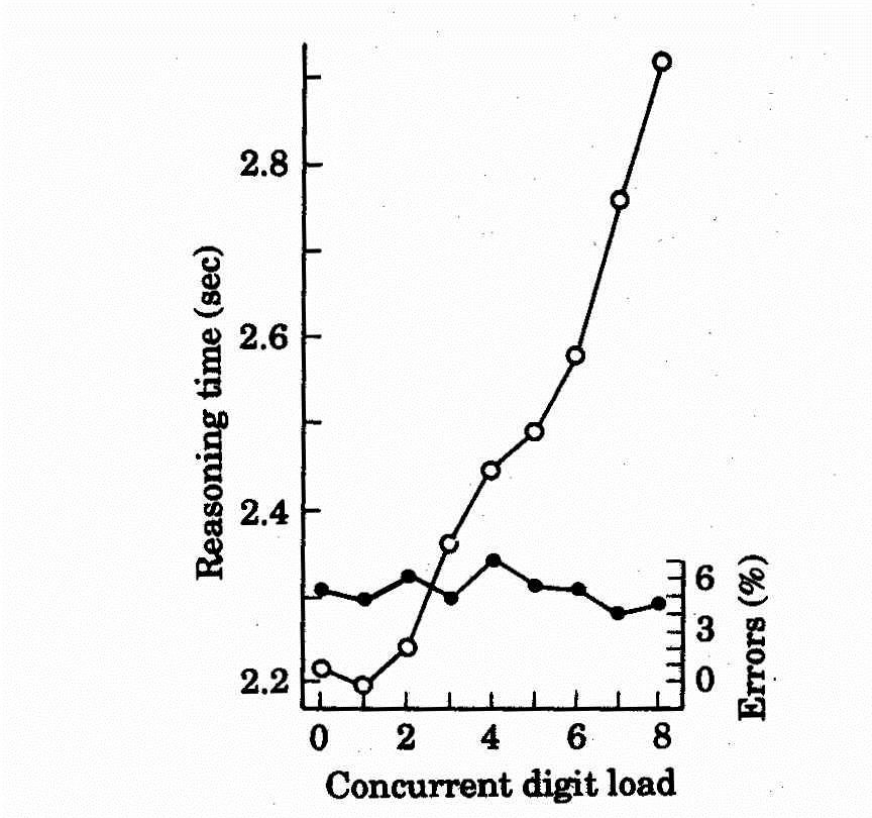
- A riddle - how come that patients such as KF (patient with digit span of 2 items only) function well in most daily tasks?
- reasoning task – participants asked to verify sentences that describe two successive letters
- concurrently, asked to remember list of random digits, varying in length between 0 and 8 items
- if STM is central for reasoning: digit manipulation should fill up STM buffer, and effect on reasoning task should be catastrophic!

		True	False
A follows B	B → A		
B precedes A	A → B		
B is followed by A	B → A		
A is preceded by B	B → A		
A is not preceded by B	A → B		
B does not follow A	A → B		

Answers: T, F, T, T, T, F.

Baddeley & Hitch (1974) - Results

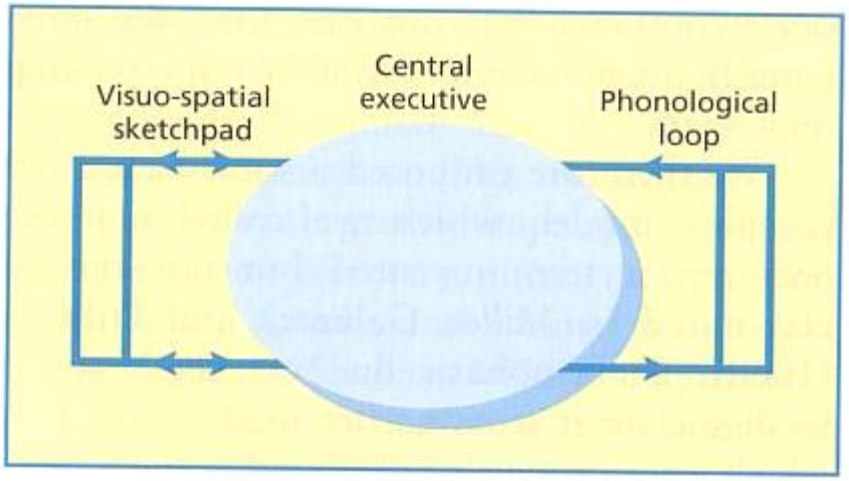
- performance adversely affected by concurrent load (reasoning time rises with increasing list length – 35%)
- but overall performance still surprisingly good
- implication: STM is not as central to complex tasks such as reasoning as previously assumed



Working memory model (Baddeley & Hitch, 1974)

- STM consists of more than one component
- central executive: integrates information. “Amodal” (not tied to a particular type of code; language, vision, etc.).
- supplemented by two “peripheral” systems:

***visuo-spatial sketch pad**:* STM store for the manipulation of *visual and spatial* information



***phonological loop**:* STM store for *speech-based* codes

Working memory model

- earlier research (digit/letter/word retention; superspan lists, etc.) primarily explored the phonological loop component
- but: this is just one component of the WM system!
- multiple components explain why neuropsychological patients with reduced digit span still function well in most everyday activities – phonological loop is impaired, but other components of WM are still intact

Central executive

- “amodal” - not tied to specific modality (verbal, visual, tactile, etc.)
- regulates information flow between the other components of WM (visual and phonological),
- retrieves information from LTM and supports subsequent manipulation
- constrained by available capacity - the more demands are placed on the system, the less efficient it will perform

Control of action in everyday life

- most activities in everyday life are governed by well-learned (automatic) schemata and habits (e.g., driving a car)
- multiple automatic schemata need to be negotiated with each other (driving to a destination vs. stopping at a red traffic light) – mostly done automatically
- but: need to be able to interrupt when necessary (e.g., road is closed for repairs)
- instances of when action control breaks down:
  - absent-mindedness
  - patients with *frontal lobe* damage, resulting in repetitive performing of the same act, or making the same mistake repeatedly

Visuo-spatial sketchpad

- specialises in the temporary holding and processing of visual and spatial codes
- remembering shapes and colours, tracking moving objects in space, planning spatial movements and navigating environments
- performance on a primary task involving the VSS can be disrupted by concurrent activities such as
  - finger tapping
  - pointing
  - eye or arm movements

Phonological loop

- specialises in the storage of speech-based code
- corresponds (more or less) to what had been traditionally studied in STM research (e.g., digit span tasks, serial position curves, etc.)
- does the PL really hold ~7 items?

Word length effect (Baddeley et al., 1975)

- better STM performance for shorter, compared to longer words. E.g.,

wit sum pill bag top

easier to recall (i.e., more words recalled on average) than

university opportunity aluminium constitution auditorium

- Why a word length effect? Implies that it's not primarily the no. of items held which constrains PL capacity…

Capacity of STM

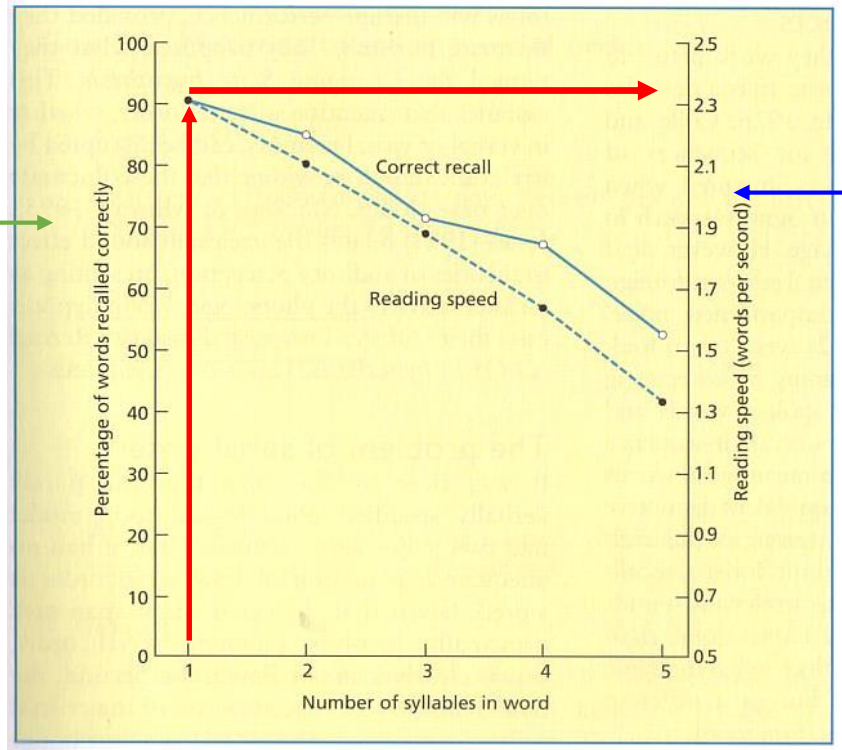
- traditional view of STM capacity (remember Miller's magic number 7): STM is limited by fixed number of items

- revised, time-based, view:
  - no inherent structural (built-in) limitation of the PL
  - instead, STM capacity is constrained by *the time it takes to report the items*
  - measured capacity: determined by number of items that can be said before lost from the phonological loop

Baddeley et al. (1975)

- amount of items correctly recalled (i.e., 90% or higher accuracy) is not 7 but rather corresponds to *what can be uttered in about 2 seconds*
- five-word lists, words ranging in length from 1 to 5 syllables
- either recalled (left), or read (right)

STM recall: short words better recalled than long words (WL effect)



Reading speed: short words take less time to read than long words

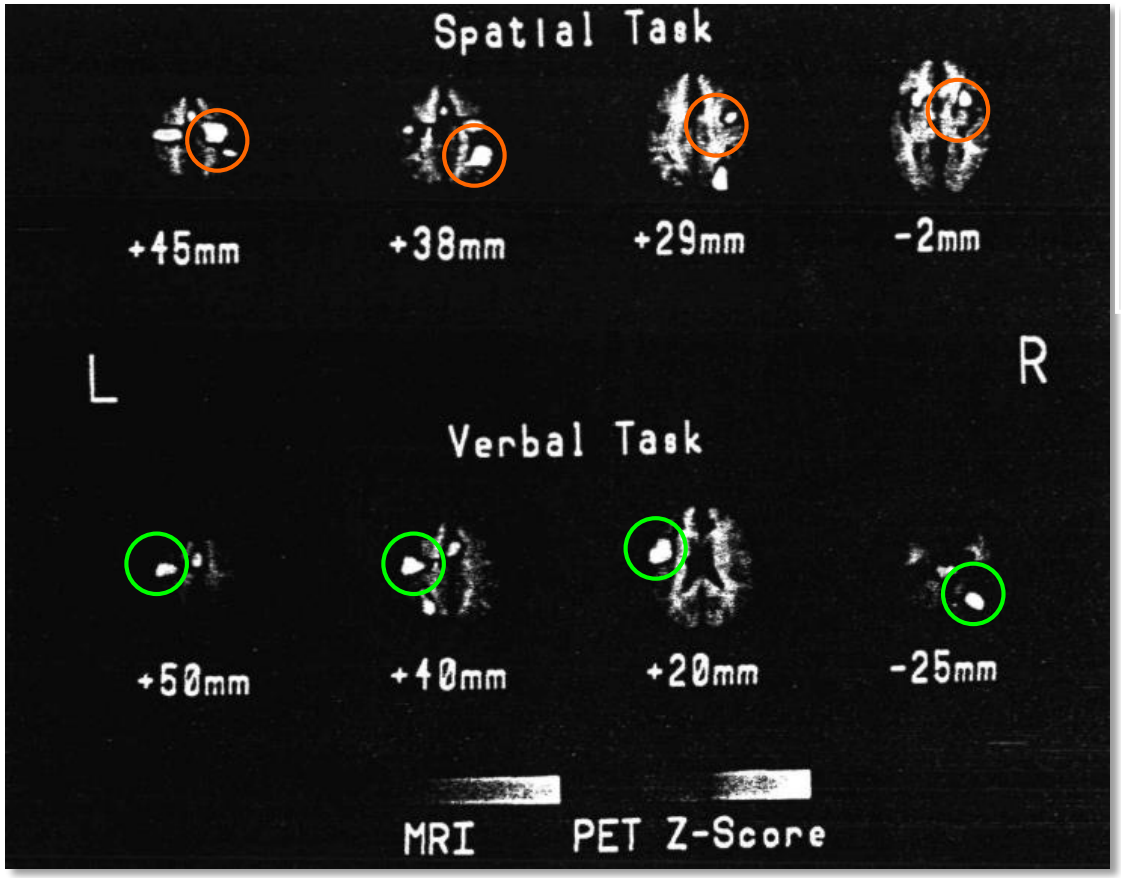
Neuroimaging of working memory

- starting in the 90s, methods became available which allow observation of functions in healthy brains
- E.g.: PET (positron emission tomography)
- weak radioactive tracer introduced into bloodstream prior to testing
- measures uptake of blood in different brain regions, reflecting cognitive/neural activity

Neuroimaging of working memory

- investigating the anatomical and neurophysiological basis of WM
- if WM really consists of separate components, should be possible to demonstrate separate brain areas
- E.g., Smith, Jonides & Koeppe (1996): compared two working memory tasks, one visuo-spatial and one verbal, both carried out in a PET (positron emission tomography) scanner

Smith, Jonides & Koeppe (1996)



Spatial task: significant foci of activation are in the **right** hemisphere

Verbal task: significant foci of activation are (predominantly) in the **left** hemisphere

- verbal and visuo-spatial types of WM are not only functionally different, but also supported by separate neural areas

Summary and key points

- the distinction between STM and LTM is fairly intuitive – although by no means universally accepted (e.g., Lewandowsky et al., 2004)
- STM capacity is restricted to just a few items – but possibly an "output constraint" (see Baddeley et al'.s, 1975, claim that measured capacity reflects what can be said in about 2 sec)
- STM may itself fractionate into multiple components (central executive, phonological loop, visuo-spatial sketchpad - plus more recently, an "episodic buffer"; Baddeley, 2000) – most prominently, in Baddeley's "working memory model"
- some evidence from neuroimaging studies that tasks which tax different types of short-term storage are carried out in separate parts of the brain

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