Outline – Working Memory

- What is Working Memory (WM)?
- Why is WM important?
- Capacity limits of WM
- Contrasting WM and LTM
- Forms of WM
- Systems vs. Emergent Accounts of WM

Importance of WM

Working memory capacity (WMC) is correlated with

- Reading comprehension and numeracy (Daneman & Carpenter, 1980; Cowan & Alloway, 2008)
- Reasoning and problem solving (Kyllonen & Christal, 1990)
- General intelligence
  - Fluid intelligence (*Gf*) refers to the ability to reason and to solve new problems independently of previously acquired knowledge
  - WMC x fluid intelligence: r = 0.59 (Engle et al., 1999)
- Academic success (Alloway & Alloway, 2010)
  - WMC at 5 yrs of age is a better predictor of academic success than IQ

Can You Make Yourself Smarter?

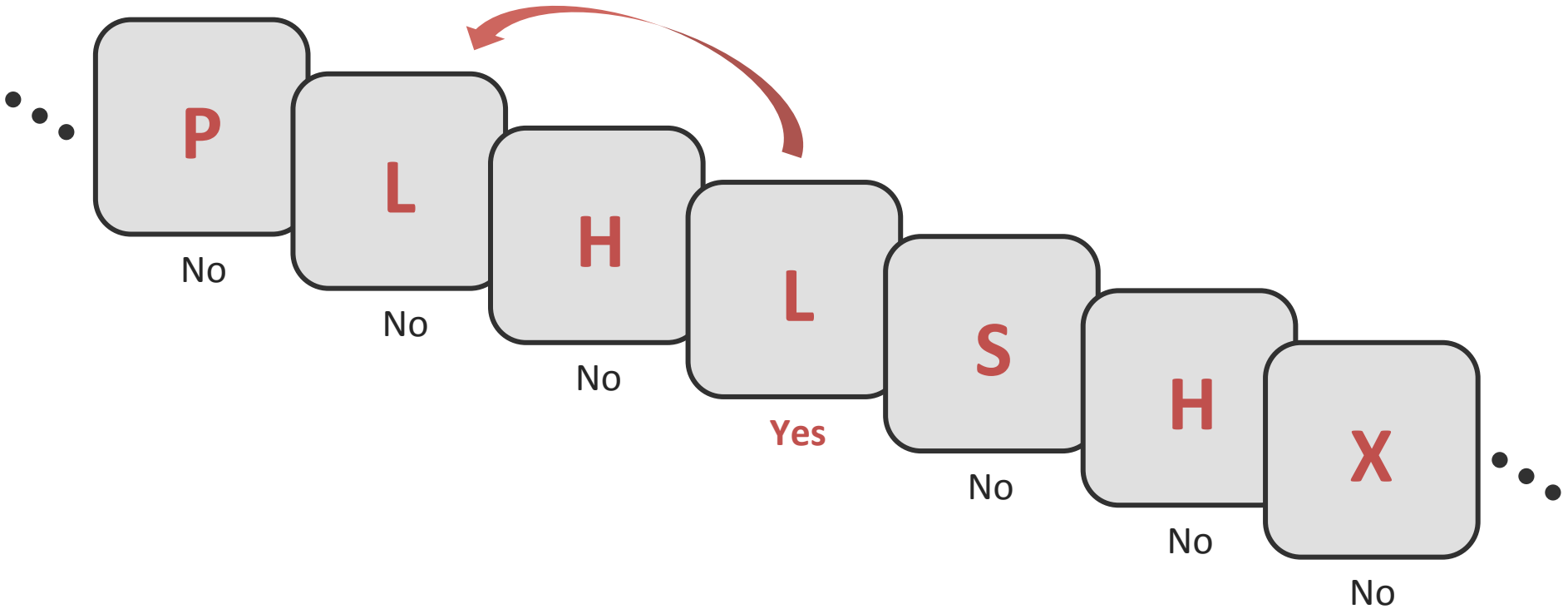
Photo illustration by Clang

New York Times, April 18, 2012

WM Training and Cognition

Does WM training increase *Gf* ? (Jaeggi et al., 2008)

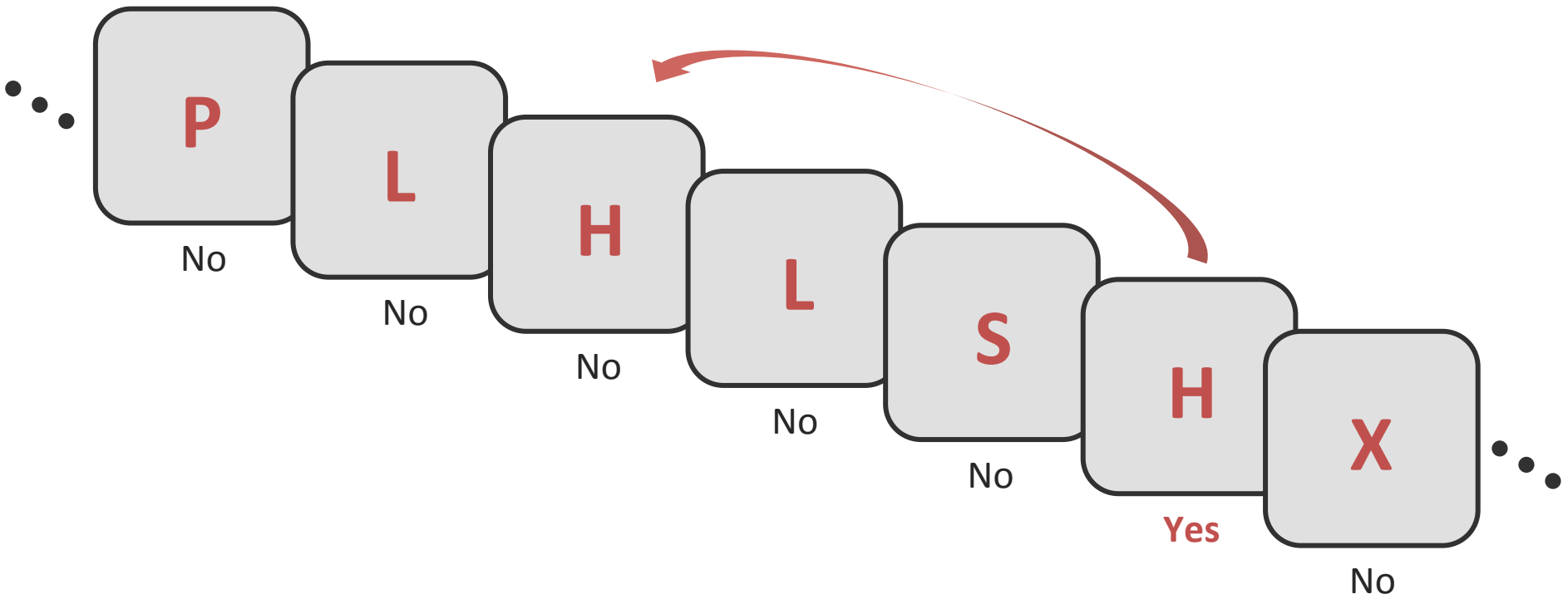
- 2-back



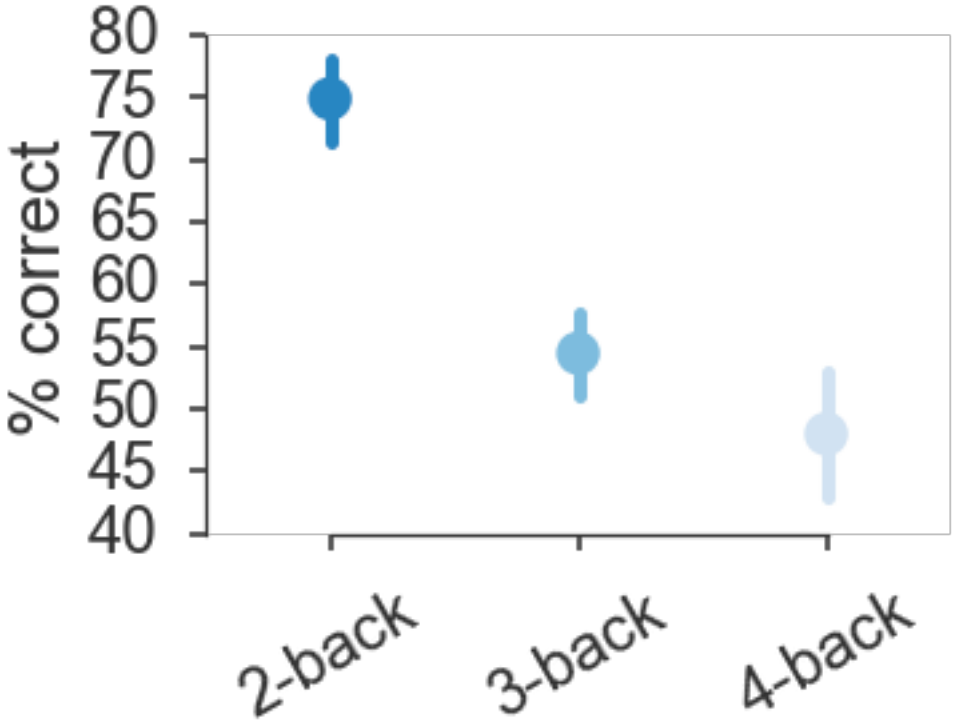
WM Training and Cognition

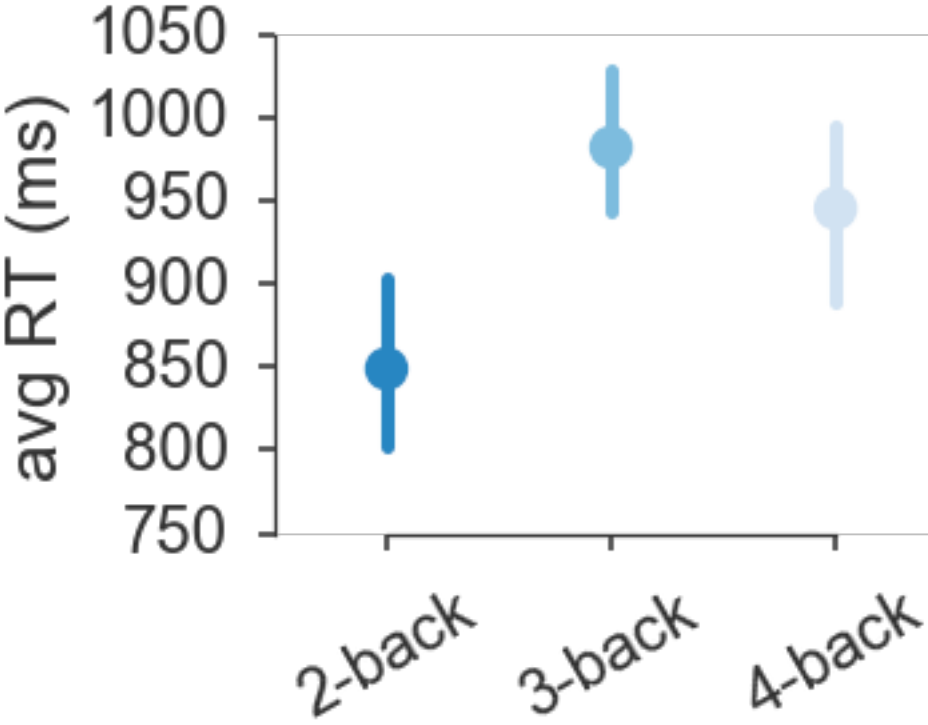
Does WM training increase *Gf* ? (Jaeggi et al., 2008)

- 3-back



Class Performance

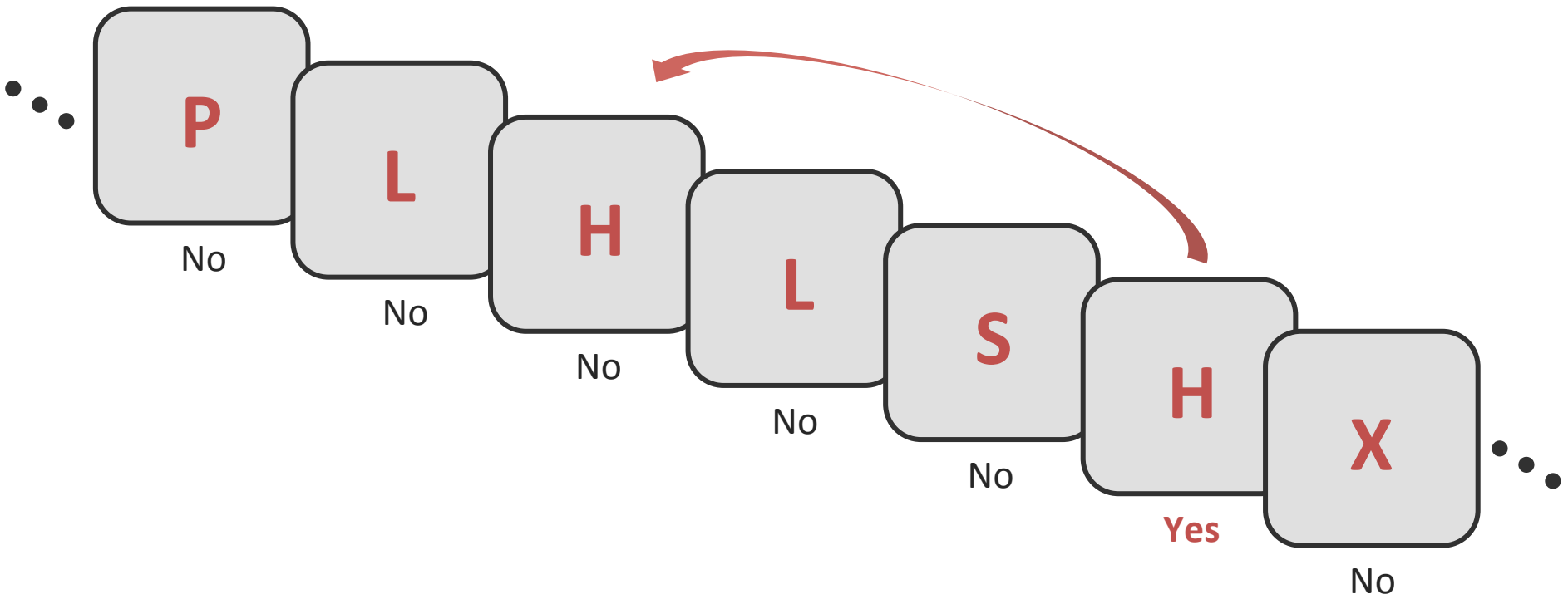




WM Training and Cognition

Does WM training increase *Gf* ? (Jaeggi et al., 2008)

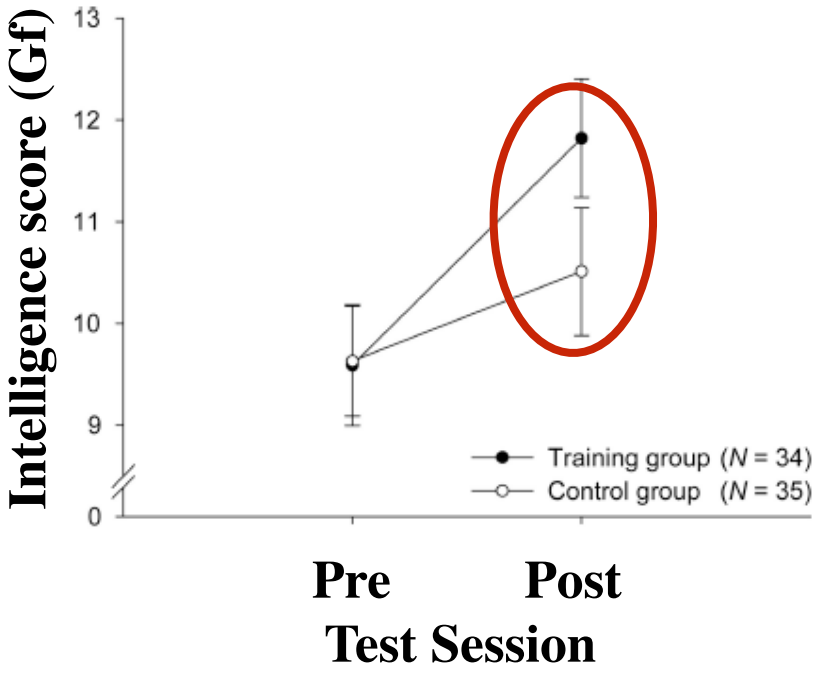
- 3-back



*Training group: Trained on dual 3-back WM task between **Pre-** and **Post-** Gf test sessions (# of training days varied across subjects)*

WM Training and Cognition

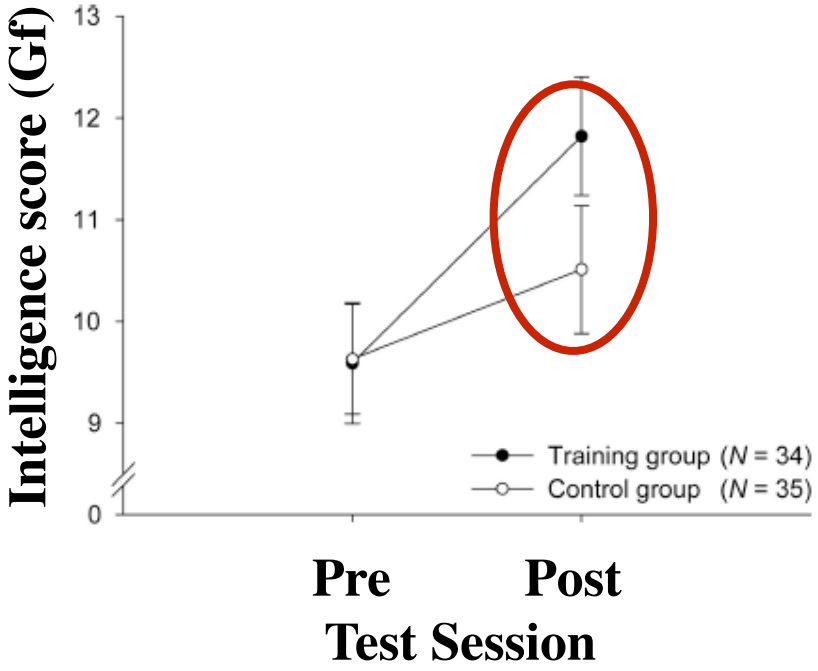
Does WM training increase *Gf* ? (Jaeggi et al., 2008)

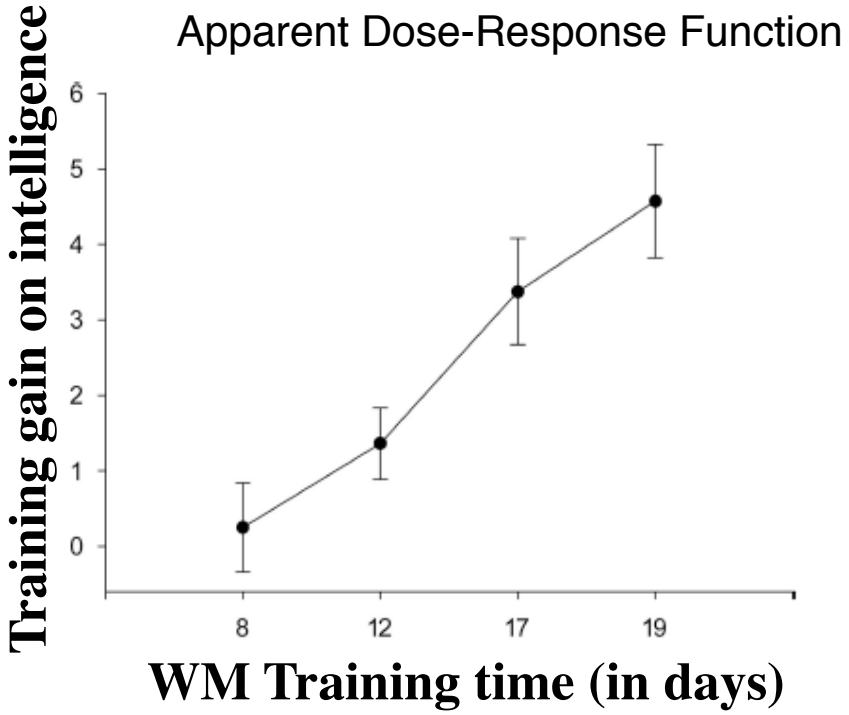


*Training group: Trained on dual 3-back WM task between **Pre-** and **Post-** Gf test sessions (# of training days varied across subjects)*

WM Training and Cognition

Does WM training increase *Gf* ? (Jaeggi et al., 2008)

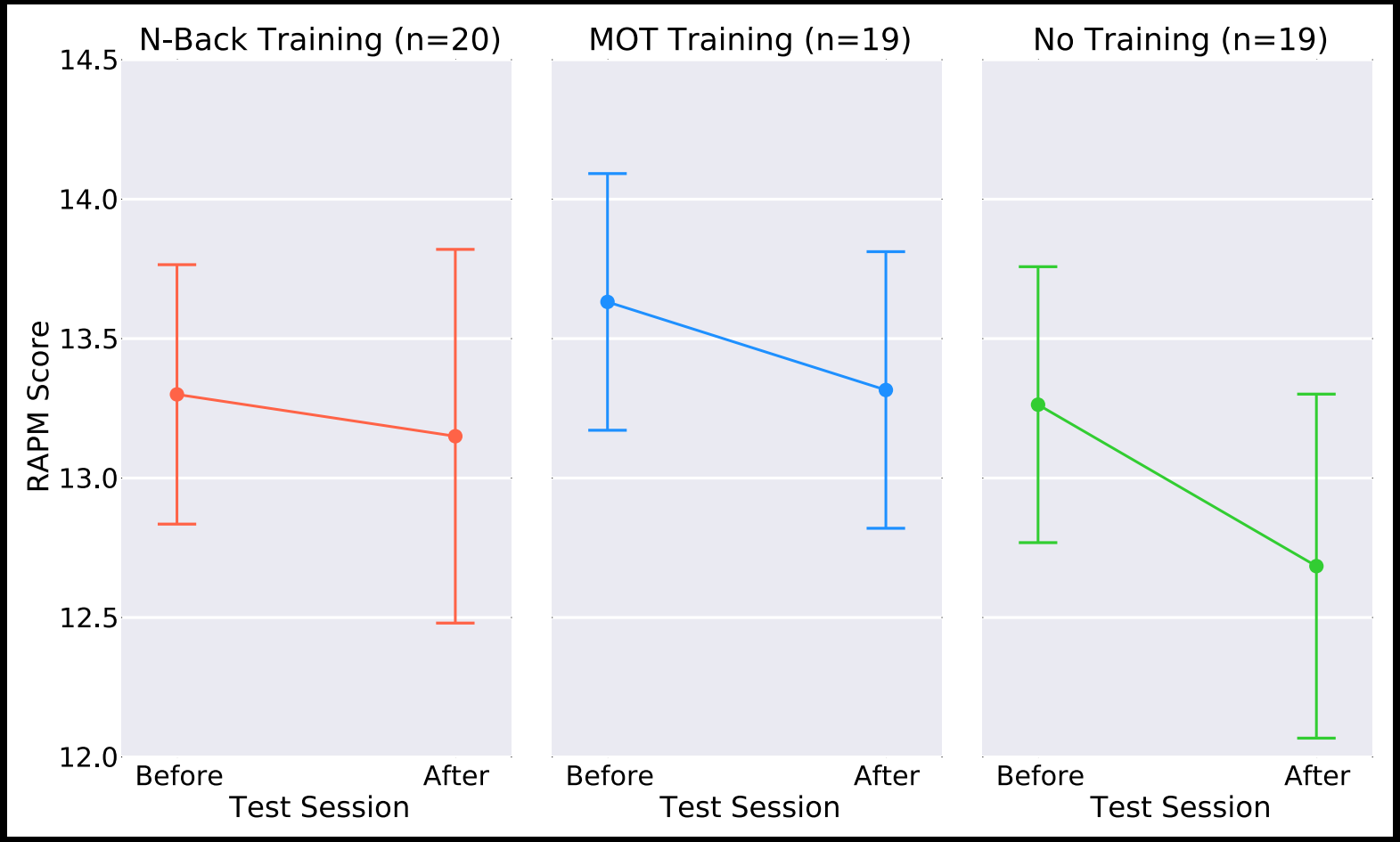




*Training group: Trained on dual 3-back WM task between **Pre-** and **Post-** Gf test sessions (# of training days varied across subjects)*

Too Good to Be True?
Challenges to WM Training Effects

WM training and *Gf* (Thompson et al., 2013; see also Redick et al., 2012)



Training group: Trained on either dual 3-back WM task OR a multi-object tracking (MOT) attention task. ***Before-*** *and* ***After-*** *scores on Ravens Progressive Matrices test (Gf) did not increase*

Outline – Working Memory

- What is Working Memory (WM)?
- Why is WM important?
- Capacity limits of WM
- Contrasting WM and LTM
- Forms of WM
- Systems vs. Emergent Accounts of WM

How Do We Measure WM Capacity: 'Simple' Span Tasks

- Forward span (digits, words, symbols)
  - 174
  - 0853
  - 92421
  - 493759
  - 6715247
  - 05369417
  - 265070193
  - 8167049716
  - 04862517290

span = correct 50% of time

How Do We Measure WM Capacity: 'Simple' Span Tasks

- Forward span (digits, words, symbols)
  - 174
  - 0853
  - 92421
  - 493759
  - 6715247
  - 05369417
  - 265070193
  - 8167049716
  - 04862517290

span = correct 50% of time

"Magic number seven, plus or minus two"
(G. Miller, 1956)

How Do We Measure WM Capacity: 'Simple' Span Tasks

- Forward span (digits, words, symbols)
  - 174
  - 0853
  - 92421
  - 493759
  - 6715247
  - 05369417
  - 265070193
  - 8167049716
  - 04862517290

span = correct 50% of time

"Magic number seven, plus or minus two"
(G. Miller, 1956)

verbal WM capacity = # of items
that can be spoken in 2 sec

"Magic number seven, plus or minus two items"

(G. Miller, 1956)

What do Simple Span tests measure?
What is an item?

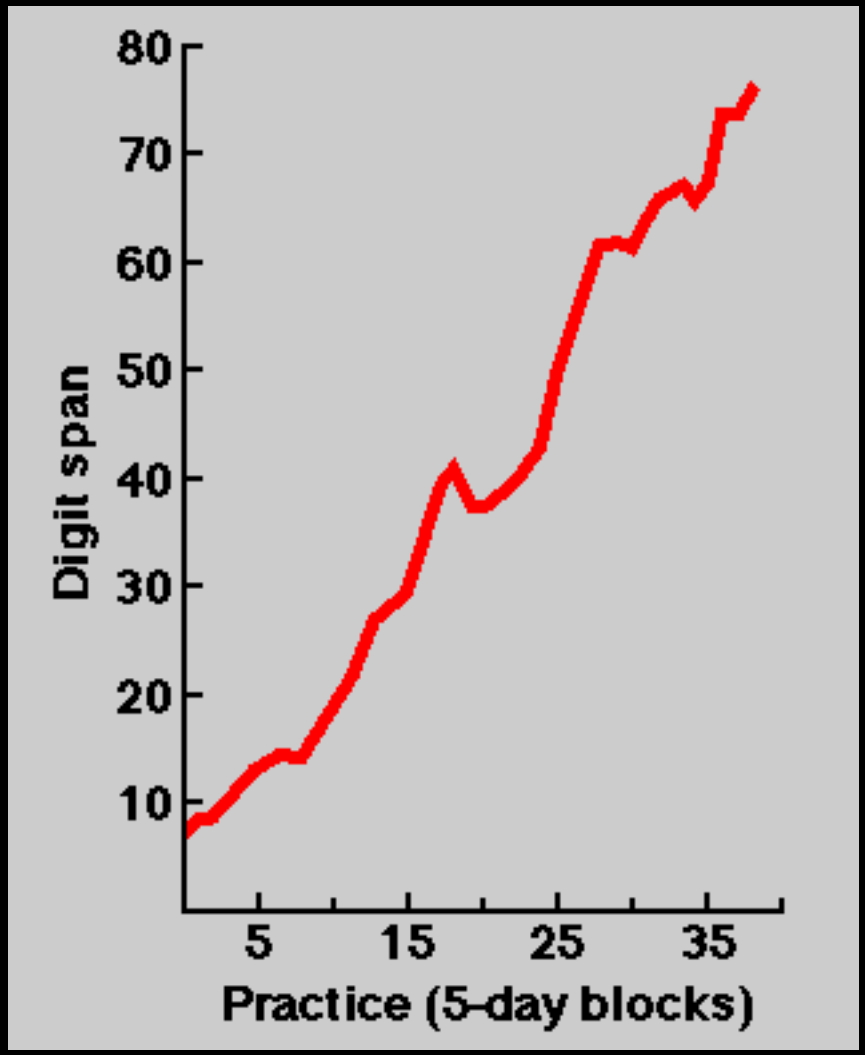
- chunks
  - a unit of knowledge that organizes together a few sub-items
  - remembering part of the information assists is remembering the rest
  - capitalizes on LTM
- span increases by increasing the # of items in a chunk
  - CA-TFL-YBU-G vs. CAT-FLY-BUG
  - information can be coded in various ways, how coded impacts span
  - interplay between STM and LTM

Effects of Chunking on ‘WM‘ Test Performance
(Ericsson & Chase, 1982)

- Can a normal person become a memory expert with training?
- Studied “SF”, a student with normal intelligence and a normal digit span of 7 digits
- Trained one hour a day, 3 to 5 days a week, for 20 months—about 230 hours of total training

Effects of Chunking on ‘WM‘ Test Performance

(Ericsson & Chase, 1982)



- with practice “WM capacity” improved
- achieved by chunking numbers as running times, etc.

Did practice increase WM capacity?

- normal letter span: not a change in WM capacity per se

San Antonio Express-News

Monday, February 22, 1999 5A

Two-time memory champion still lives by Post-its

Long on facts, but short on remembering the milk

If we want to know what memory can and cannot do, there may be no better example than Tatiana Cooley, 27, a vivacious working woman in Manhattan and the USA National Memory Championship winner for the last two years in a row.

Cooley won the title by memorizing lengthy passages of poetry and complex series of numbers during a grueling competition. She discovered her ability to remember while in college, when she went into an exam and found she could recall verbatim the notes she had taken in class.

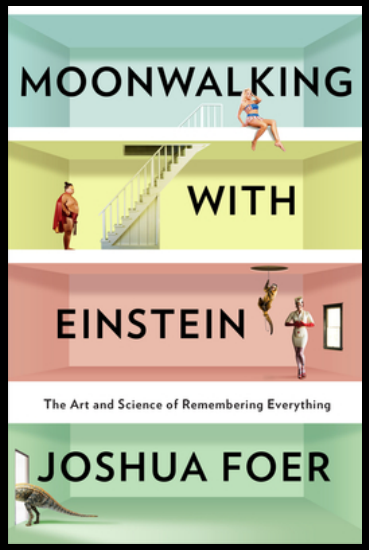
Tatiana Cooley with her 1999 memory championship award

Today, as an executive assistant in a large office, Tatiana does not have to refer to the Rolodex on her desk, as the telephone numbers are all in her head.

Still, she says, there is a big difference between her ability to memorize things and her ability to keep a simple "to do" list in her head.

"They are two different worlds," she insisted. "I'm horribly absent-minded. I live by Post-it Notes."

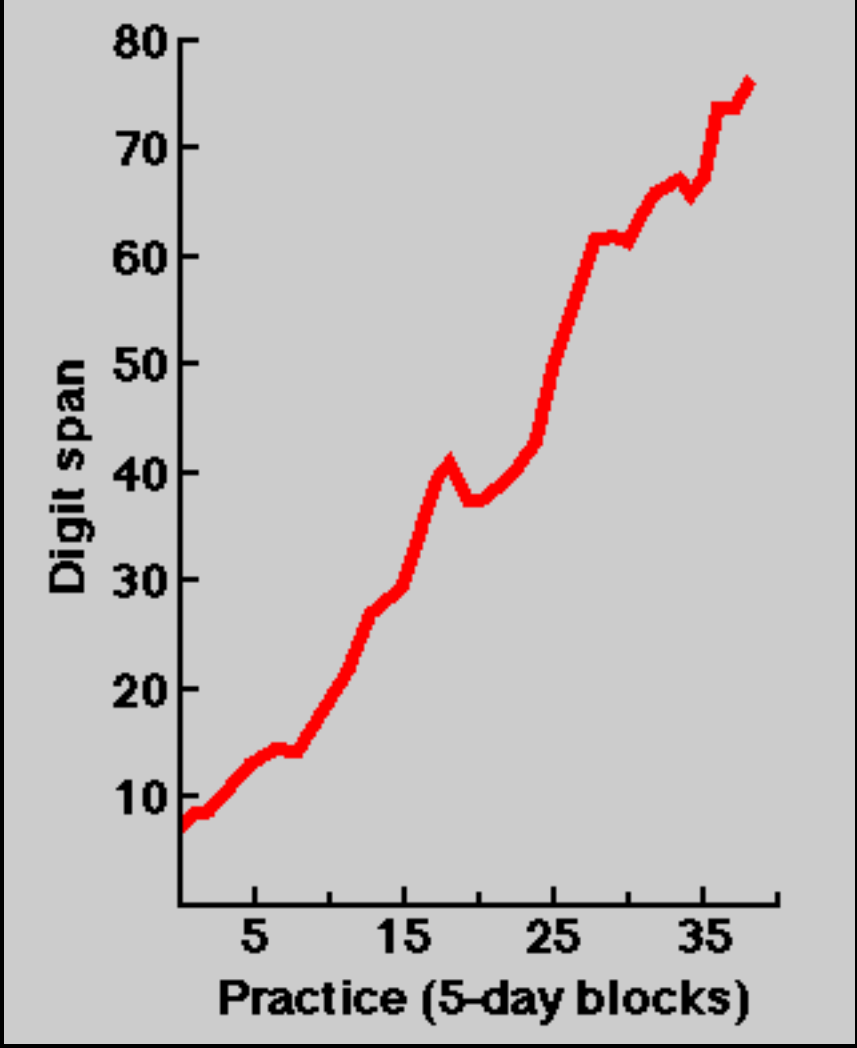
You Too Can Be a Memory Champion!



“Cookie monster is waving at you from atop his perch on a tan horse; a talking horse.” —Joshua Foer

Effects of Chunking on ‘WM‘ Test Performance

(Ericsson & Chase, 1982)

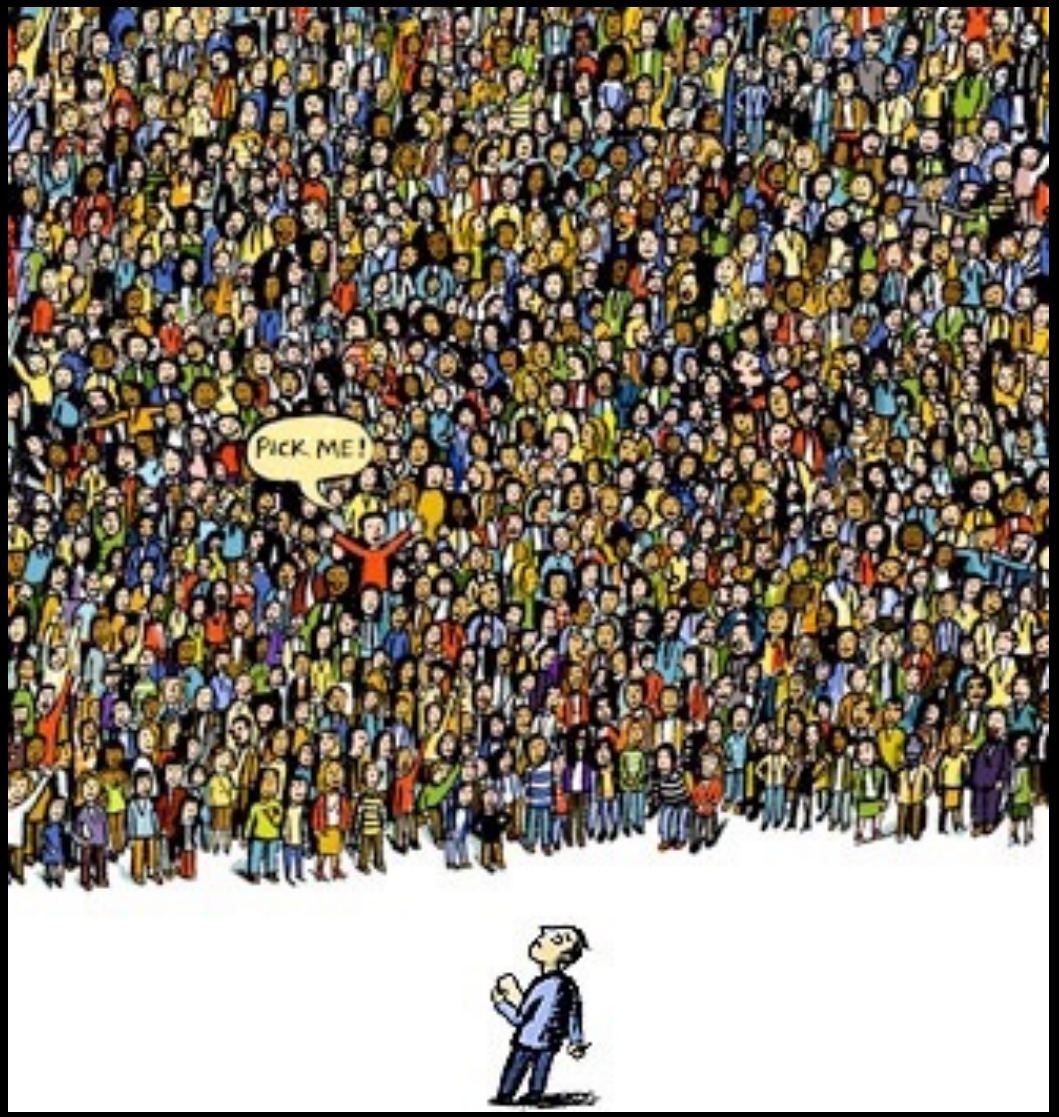


- achieved by chunking numbers as running times, etc.
- normal letter span: not a change in WM capacity
- WM is capacity-constrained; performance at short-delays can be supplemented by LTM
- performance is often a blend of contributions from multiple types of memory — WM and LTM

What Determines WM Capacity? Filtering Efficiency

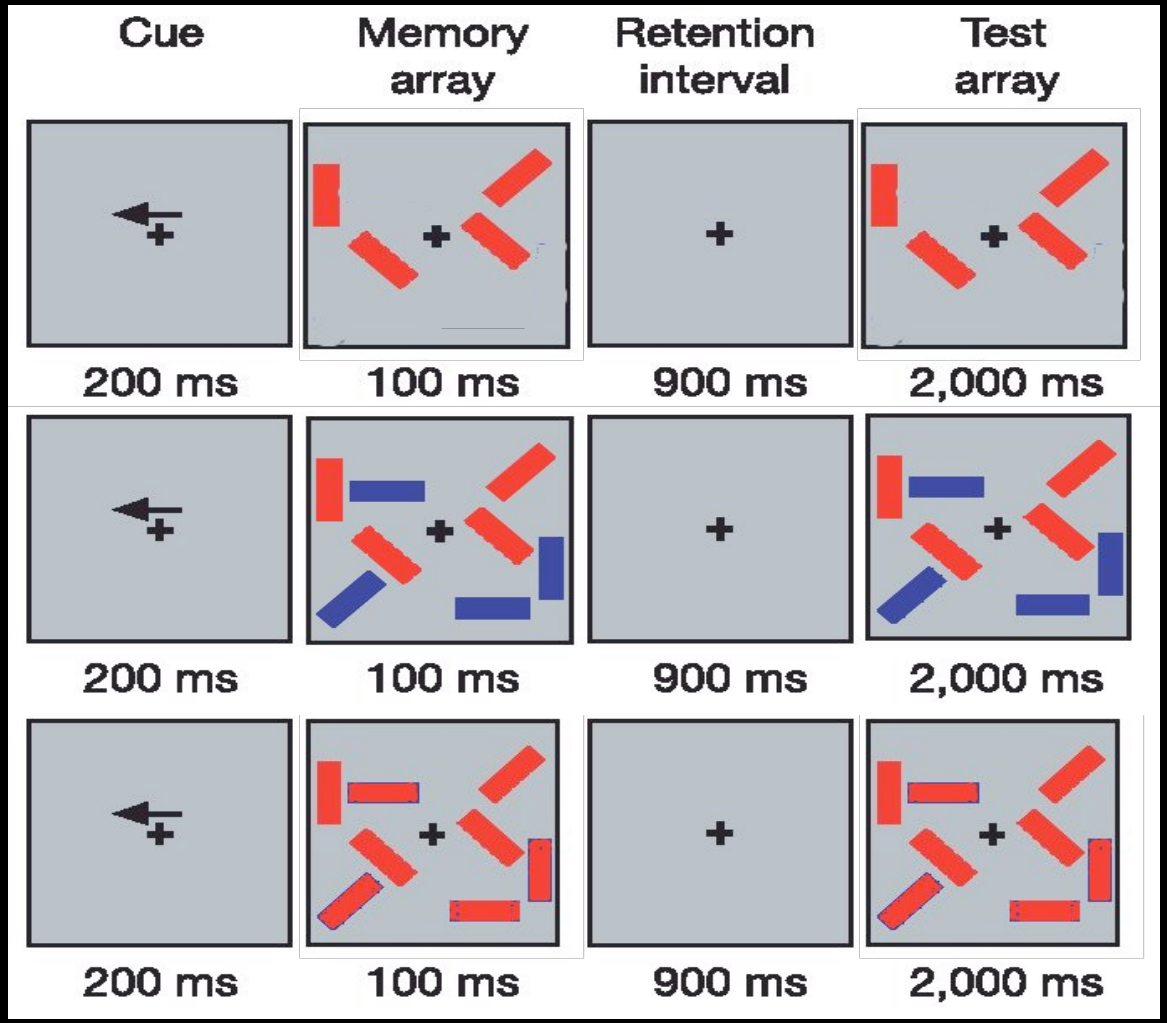
- **Hypothesis:** WM performance rests on the ability to focus attention on relevant information and prevent distraction from irrelevant information

- WM capacity is affected by how well a person can filter out distracting information (*Filtering Efficiency*)



Los Angeles Times, 4/4/09

What Determines WM Capacity? Filtering Efficiency



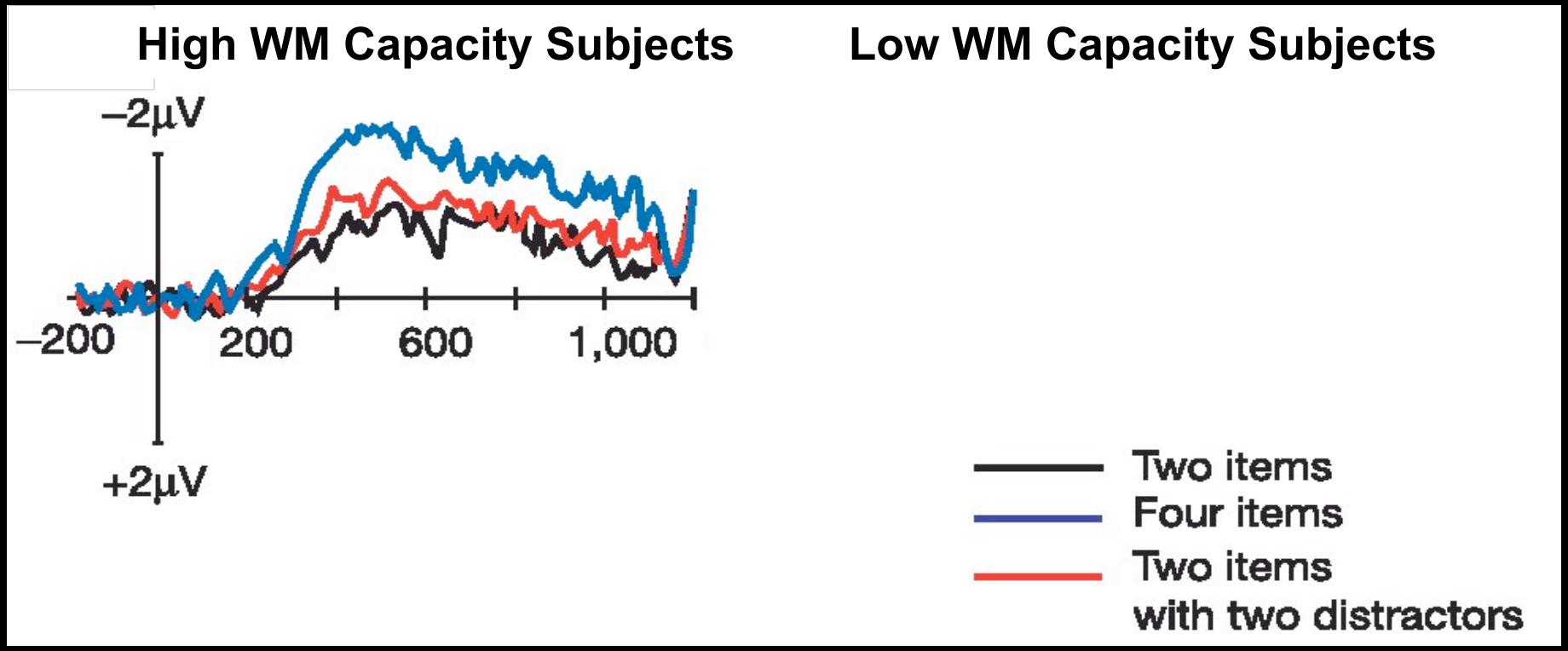
red = relevant

blue = distractors

- 2 Items
- 2 Items, 2 Distractors
- 4 Items

[Vogel et al, (2005) *Nature*]

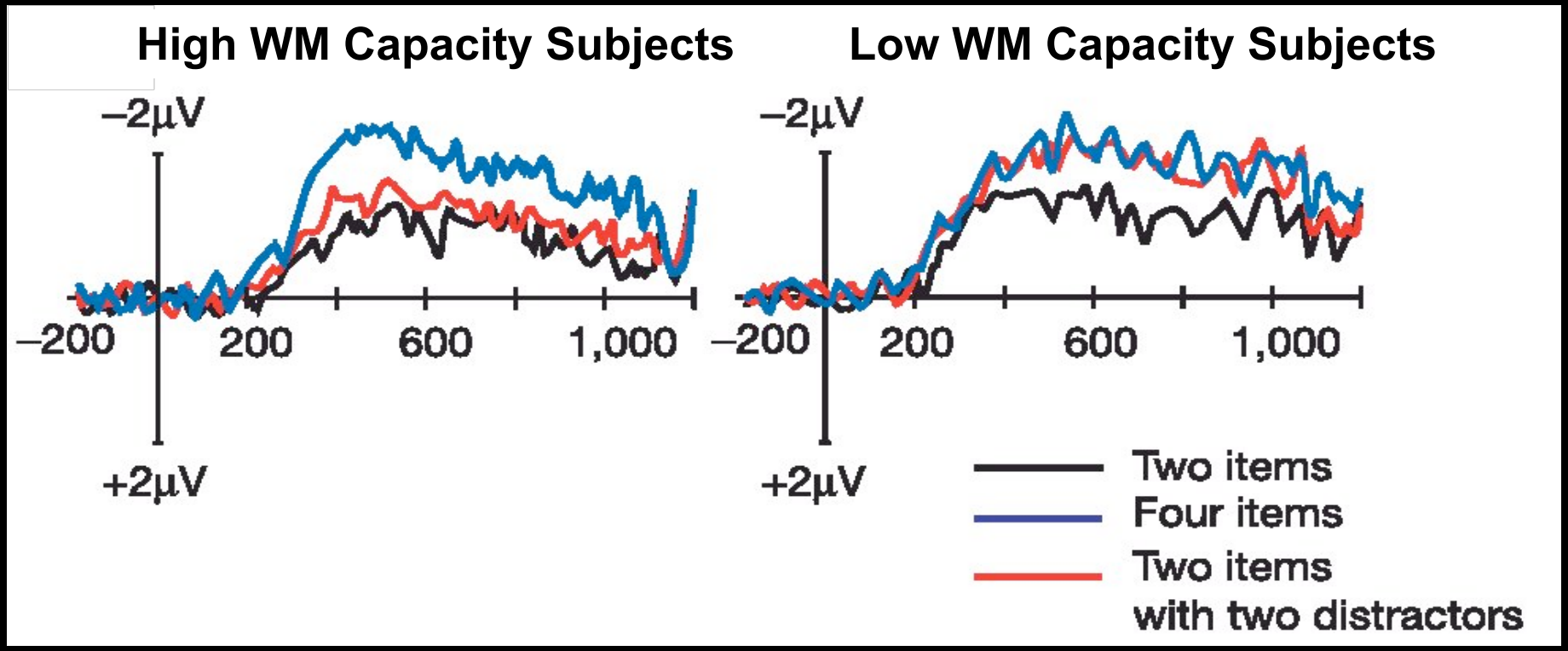
What Determines WM Capacity?
EEG Measure of Filtering Efficiency



- EEG signal magnitude scales with # of items in WM
- Can tell us whether distractors entered WM

[Vogel et al, (2005) *Nature*]

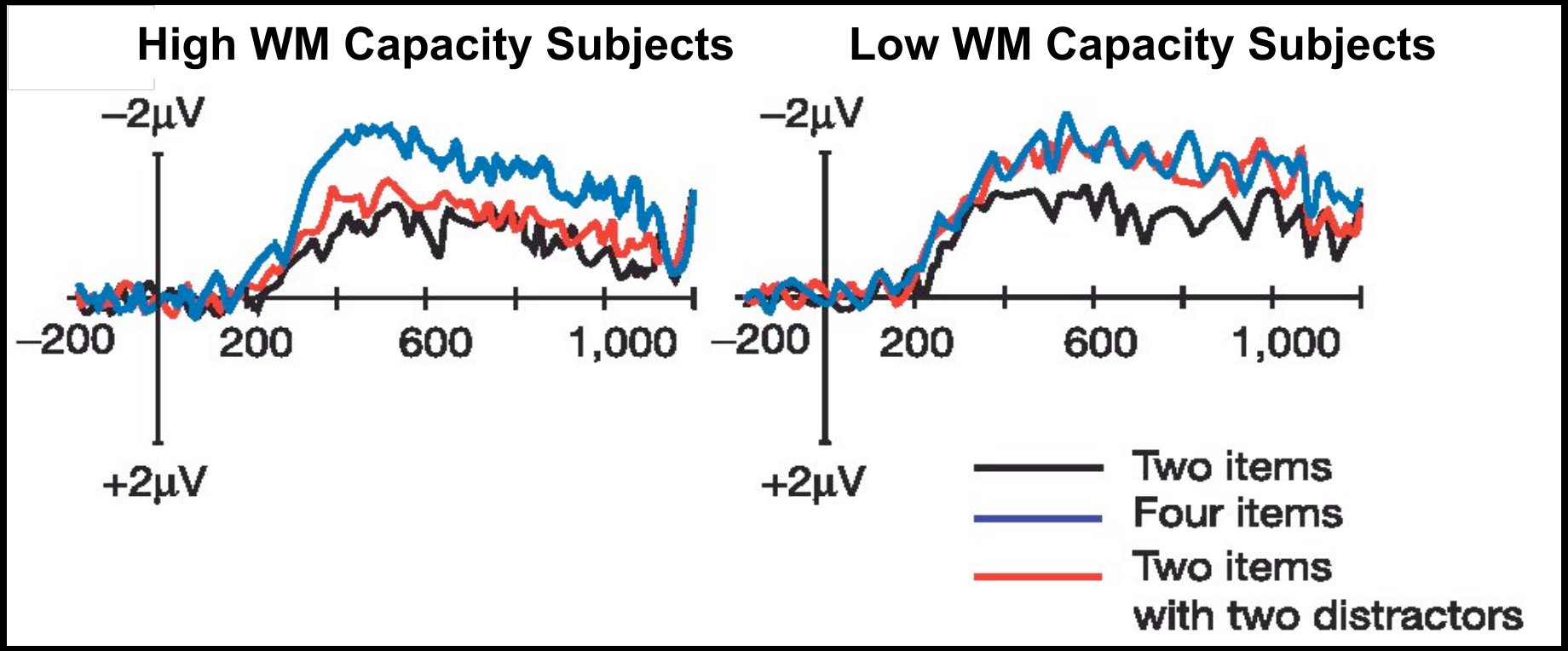
What Determines WM Capacity?
EEG Measure of Filtering Efficiency



- EEG signal magnitude scales with # of items in WM
- Can tell us whether distractors entered WM

[Vogel et al, (2005) *Nature*]

What Determines WM Capacity?
EEG Measure of Filtering Efficiency



WM capacity is partly determined by the ability to filter out irrelevant environmental inputs and thoughts

[Vogel et al, (2005) *Nature*]

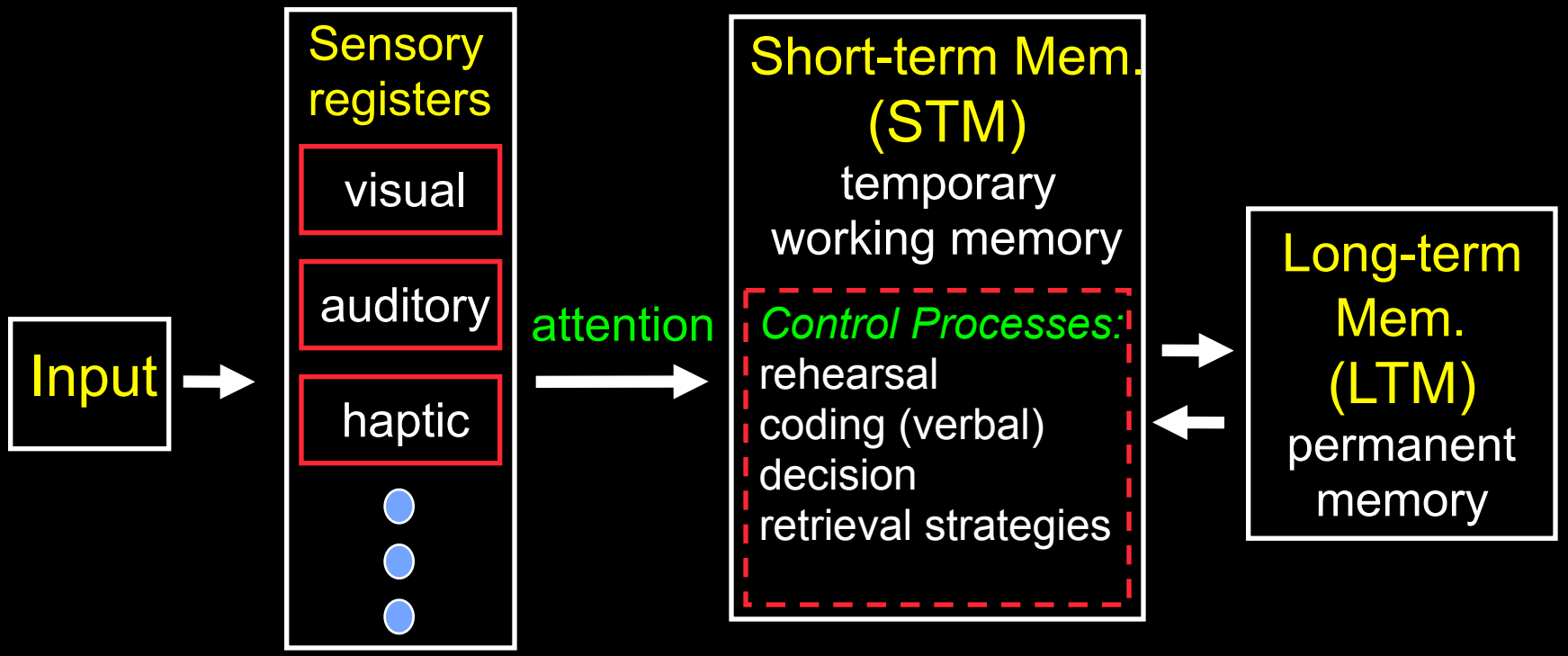
Outline – Working Memory

- What is Working Memory (WM)?
  - ability to keep active (maintain) and manipulate mental representations
- Why is WM important?
  - WM capacity correlates with other cognitive abilities
- Capacity limits of WM
  - WM is capacity limited, but performance at short delays can also be supported by LTM
  - attention is required to transform sensory information into WM representations
  - WM capacity is correlated with ability to filter out distracting information

Outline

- What is Working Memory (WM)?
- Why is WM important?
- Capacity limits of WM
- Contrasting WM and LTM
  - Evidence for separate WM & LTM systems?
- Forms of WM
- Systems vs. Emergent Accounts of WM

“Modal Model” of Memory

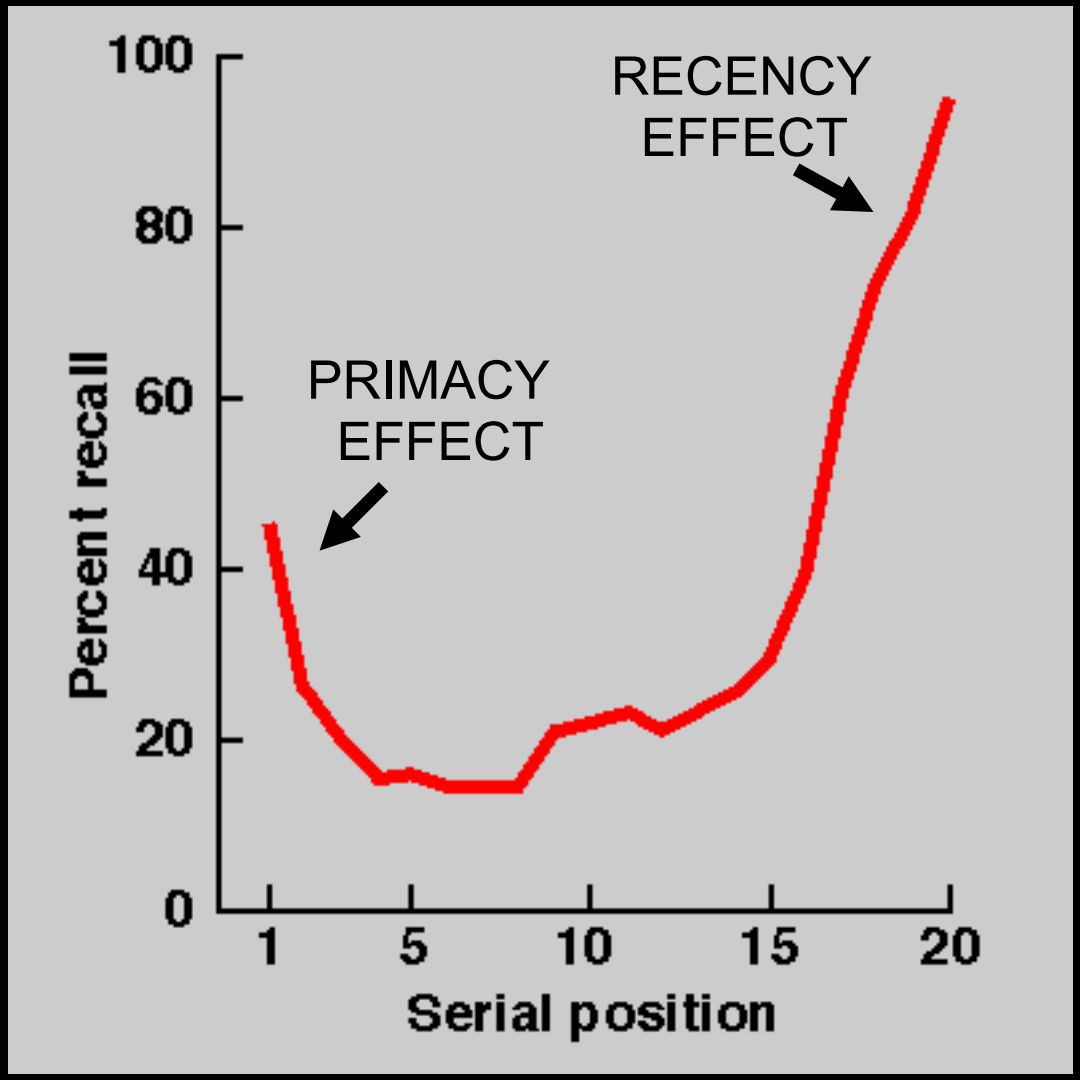


Atkinson & Shiffrin (1968)

Serial Position Function in Free Recall

If you encounter a series of events that span a brief period (e.g., a list of 20 words presented one at a time), what is the probability of recalling each event?

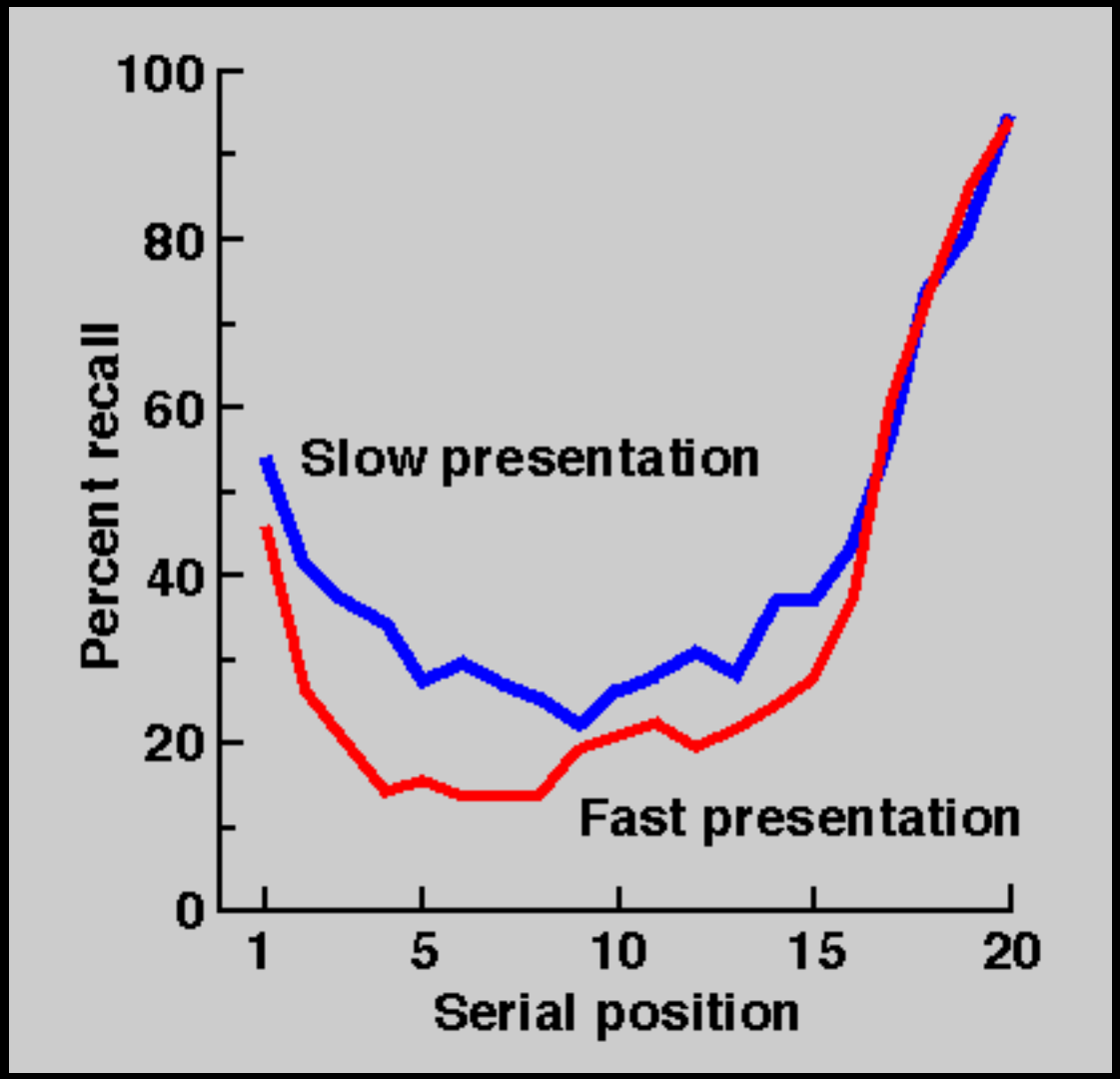
Serial Position Function in Free Recall



– Do the Primacy and Recency components of the serial position function reflect different forms of memory (LTM and WM)?

Primacy Component – LTM

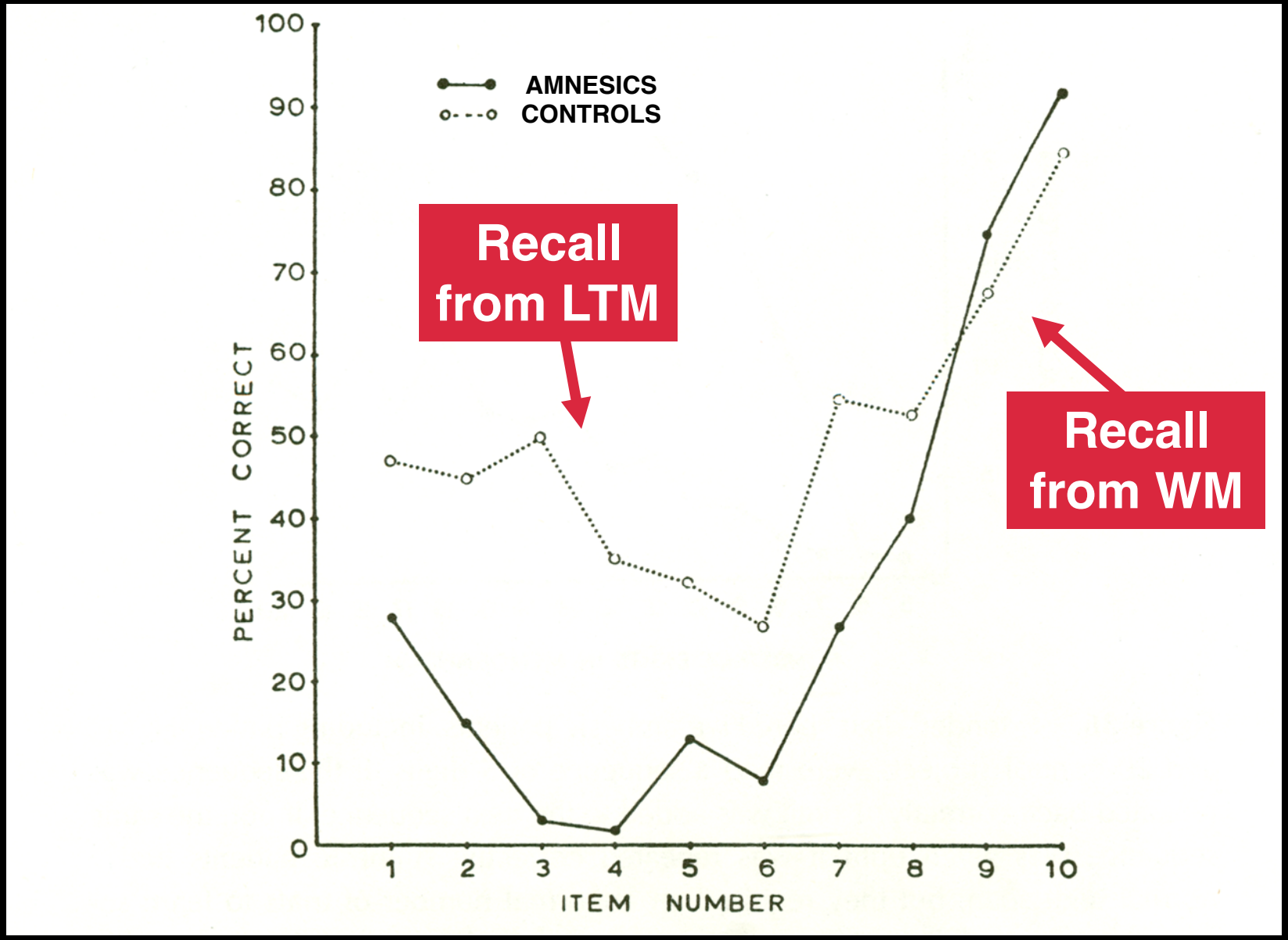
Dissociable effects of rate of presentation



Why?

- two-store model's account: longer rehearsal time in WM = greater transfer to LTM
- alternatively: elaboration; encode inter-item associations

Impaired Primacy in Amnesia



Baddeley & Warrington (1970)

Factors Affecting the Primacy Effect

- Rate of presentation
  - rehearsal time; encode inter-item associations
- List length
  - less between-item interference (forgetting)
- Familiarity of materials
  - elaborative / depth of encoding
- Aging
- Medial temporal lobe lesions (amnesia)

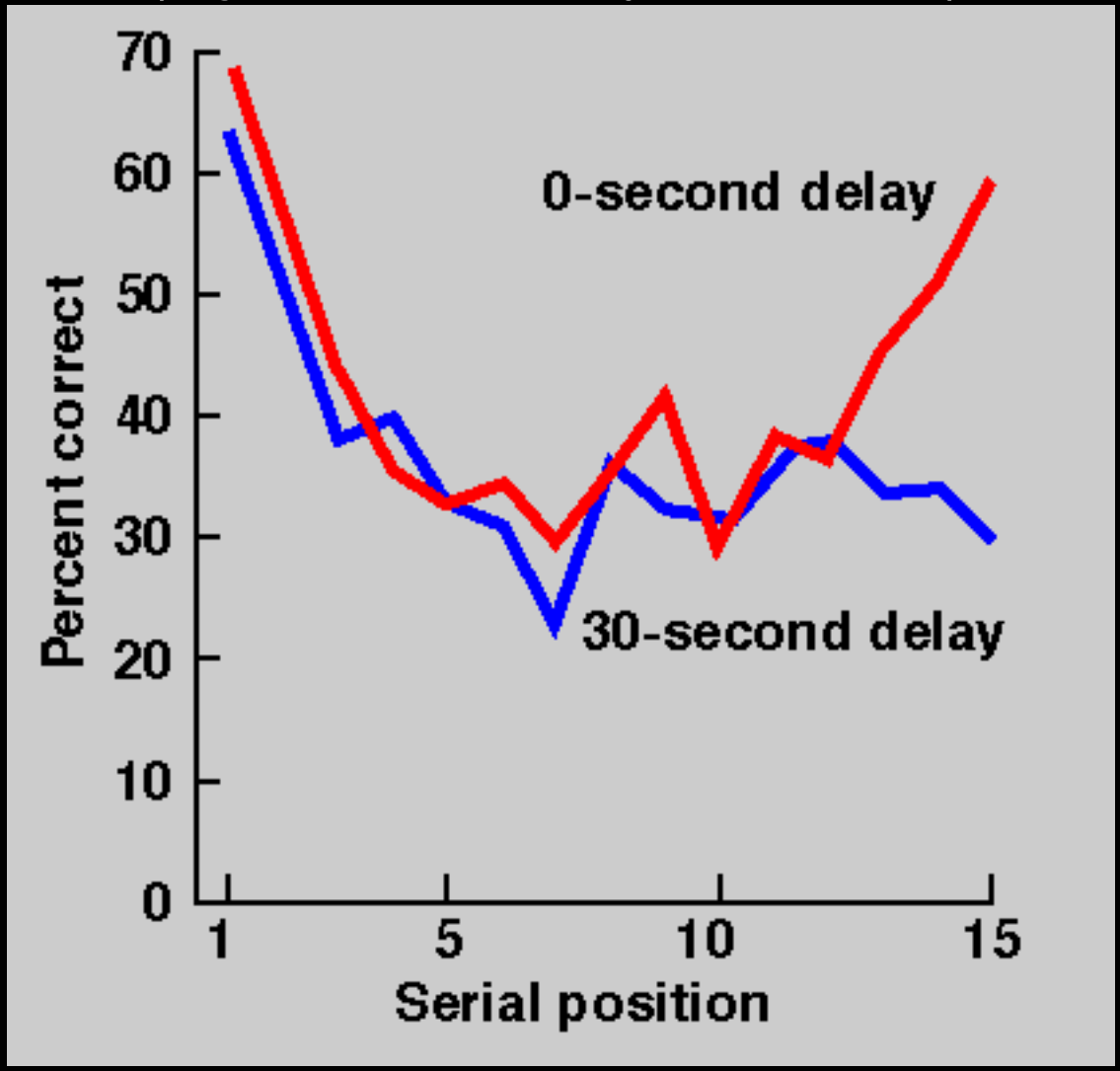
All of these affect LTM encoding/storage

Articulatory Suppression & WM

Recency Component – WM

Dissociable effects of filled delay

(e.g., with articulatory suppression)



Double Dissociation:

WM and LTM depend on different systems or processes