UNIVERSITY OF CAMBRIDGE

MRC | Cognition and Brain Sciences Unit




Memory and learning at school

Andrea Greve and Duncan Astle

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The brain, cognition and learning

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Debunking a few myths….

"What do you know about the brain?" If you ask someone this question, you are most likely to get one of the following answers: "The right hemisphere of the brain is for emotion and creativity. In contrast, logic lies in the left hemisphere." Someone else might answer: "We only use of 10% of our brains!" These statements are common misconceptions about brain mechanisms, which are taken for granted in today's society. Many such myths have evolved around the functioning of the brain. In order to classify them, the OECD coined the term "Neuromyths".

OECD Website

The brain, cognition and learning

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Top 5:

- 5) We only use x% of our brains
- 4) Short bursts of co-ordinated activity can improve the communication between the two halves of the brain
- 3) Pressing on different parts of the body can enhance specific patterns of brain activity
- 2) Individual's brains are predisposed to learn in different ways, and will learn best when information is delivered in the preferred style
- 1) Differences in hemispheric dominance can help explain differences in learning style

The brain, cognition and learning

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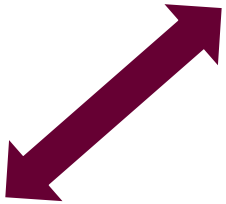
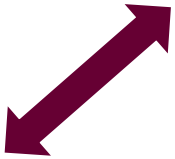
Our approach:

Education, learning,
Everyday functioning



Cognition
e.g. working memory;
episodic memory; attention;
language



Brain / neuroscience

Overview

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- I. Introduction to memory systems and processes
- II. Constraints on learning: working memory
- III. Constraints on learning: long-term memory
- IV. Learning techniques

I. Memory systems & processes

Long-term Memory

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Explicit memory

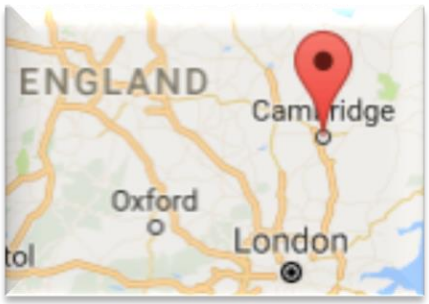
Implicit memory

Facts (Semantic)

Events (Episodic)

Skills (Habit)

Conditioning Priming



Squire & Zola-Morgan (1991). Biological Psychology

Memory systems: H.M.

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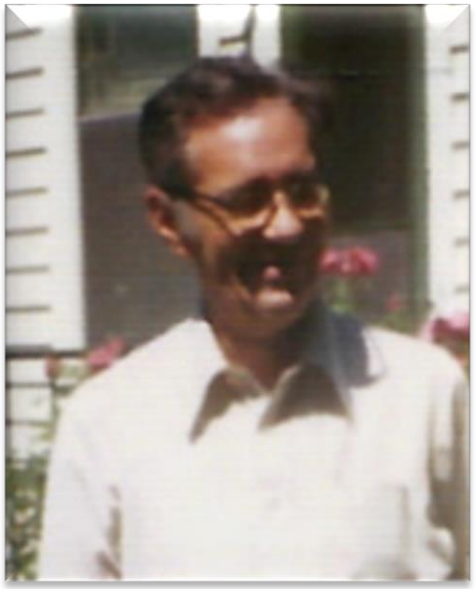
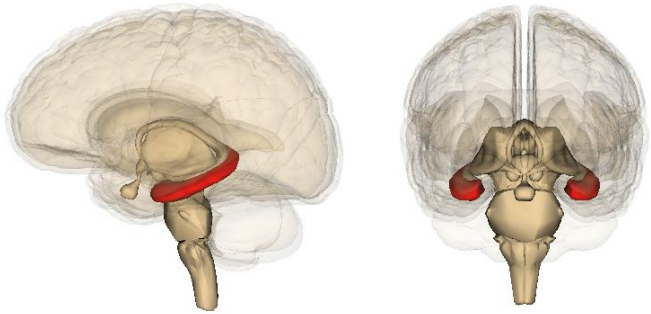


Henry Molaison (H.M.)
(1926-2008)

removal of the medial
temporal lobe and hippocampus



profound memory loss (amnesia)

Scoville & Milner (1957). J Neurol Neurosurg Psychiatry

Memory systems: H.M.

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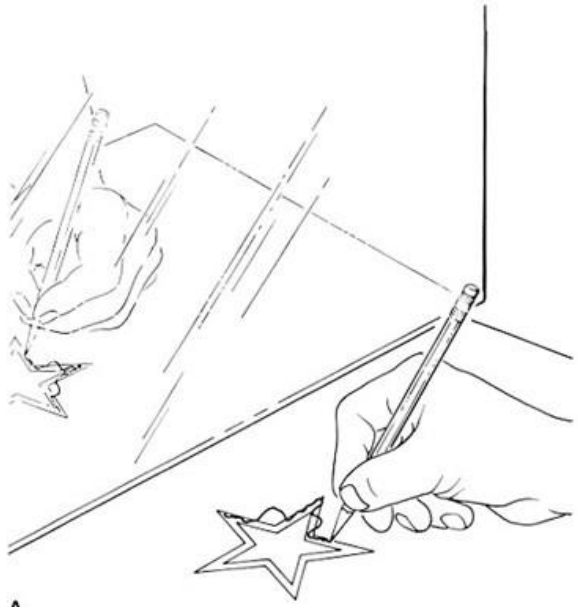
Impaired explicit memory but relatively preserved implicit memory.

Mirror tracing task



attempts at each day

Milner (1965)

Long-term Memory

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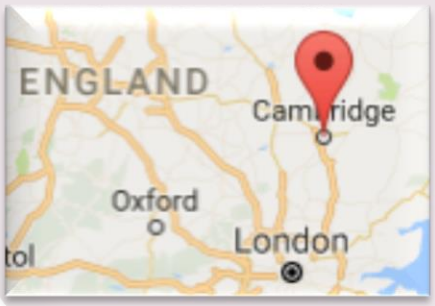
Explicit memory

Facts (Semantic)



Events (Episodic)

Implicit memory

Skills (Habit)

Conditioning Priming

Squire & Zola-Morgan (1991). Biological Psychology

Semantic Dementia

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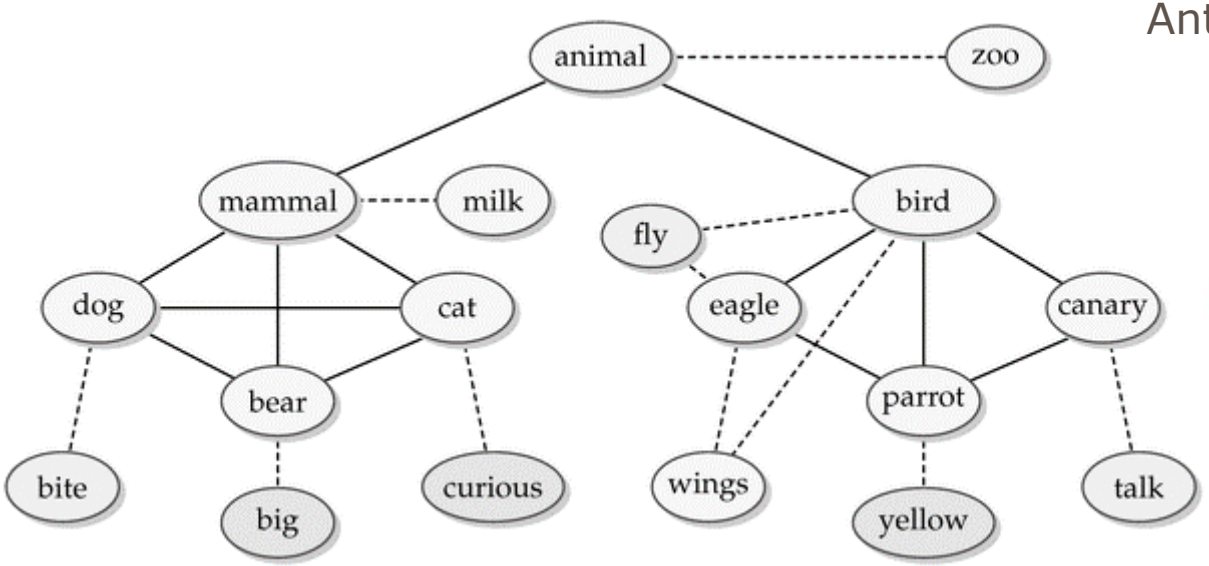
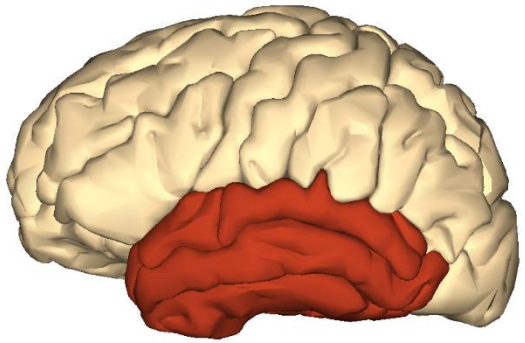
Impaired semantic memory but relatively preserved episodic memory.



Anterior Temporal Lobe (ATL)



Hodges & Patterson (2007) The Lancet Neurology

Long-term Memory

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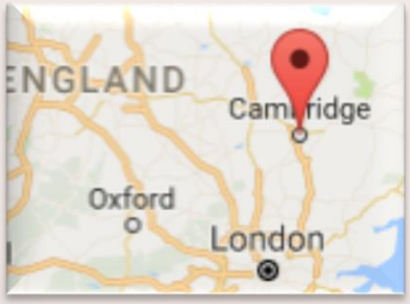
Explicit memory

Facts
(Semantic)



Events
(Episodic)

Implicit memory

Skills
(Habit)

Conditioning
Priming

Squire & Zola-Morgan (1991). Biological Psychology

II. Constraints on learning: working memory

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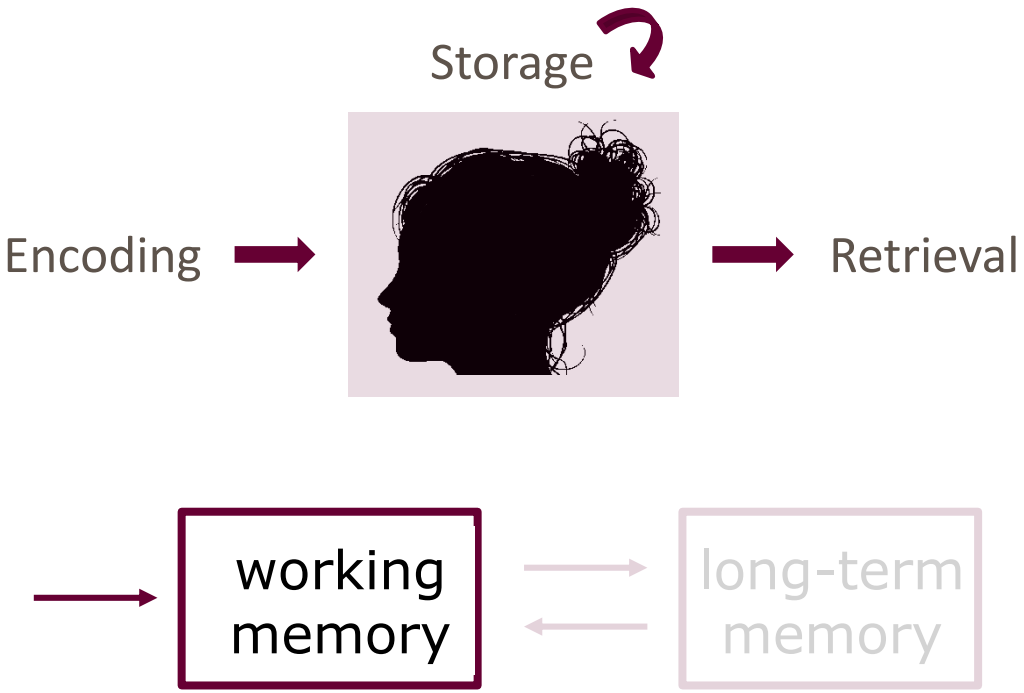

What is working memory?

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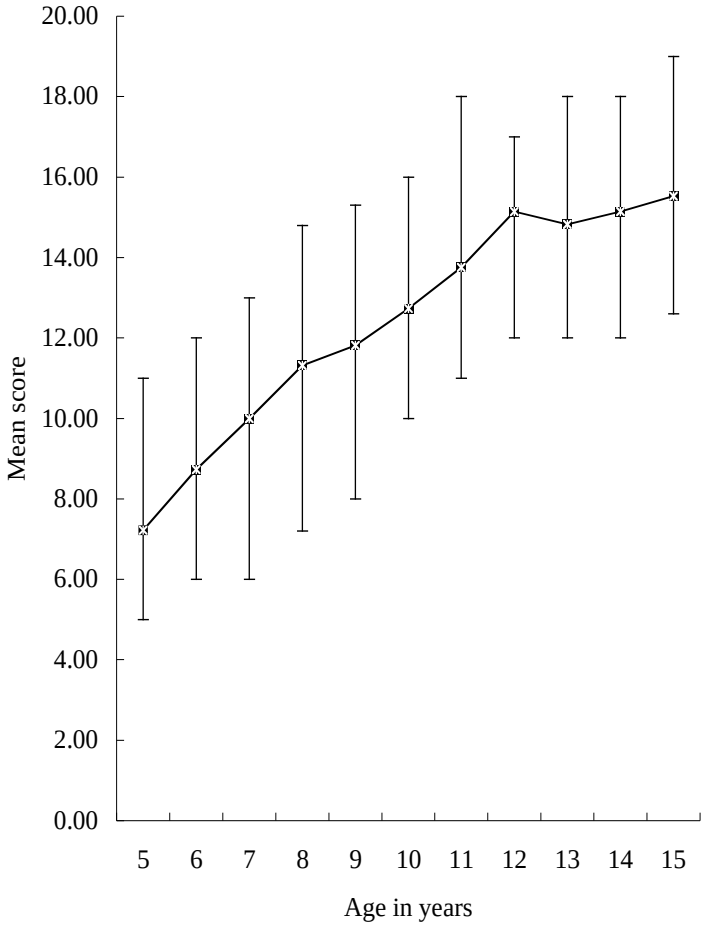
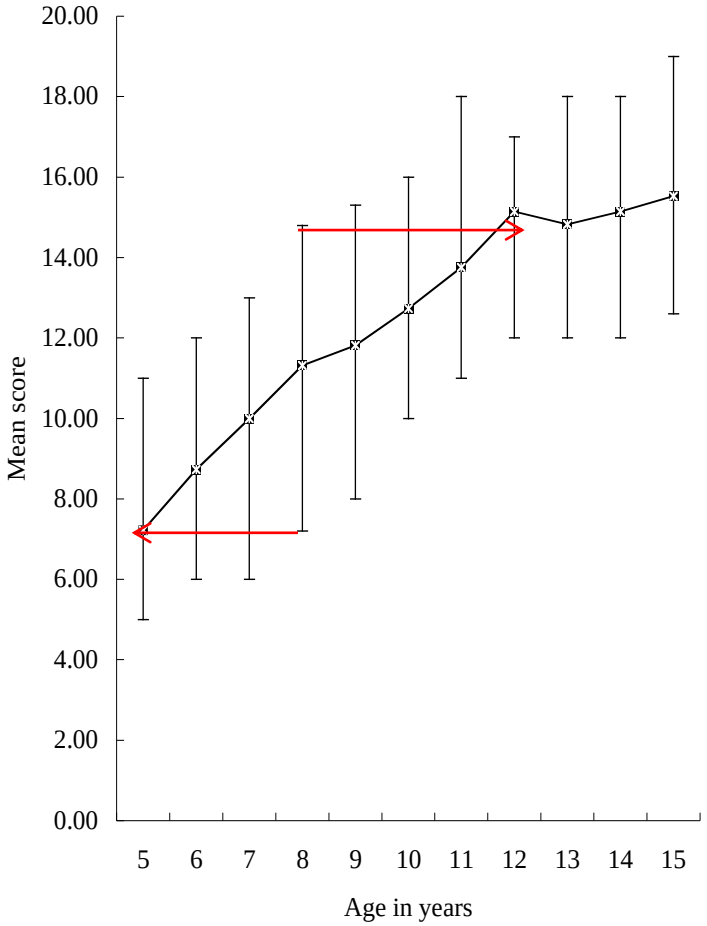
- Working memory is the ability to hold in mind and manipulate small amounts of information for brief periods of time.
- We use it all the time… especially for solving problems, dealing with novel material, and working 'online'.
- Working memory ability increases steadily with age between 4 and 14 years
- Large individual variation in ability in children of the same age

Working memory



Mean scores on listening recall test from WMTB-C as a function of age, with 10th & 90th centiles bars

Working memory



Mean scores on listening recall test from WMTB-C as a function of age, with 10th & 90th centiles bars

Why should I care?!

A child's working memory capacity is closely associated with their ability to learn

Assessing WM at school entry:

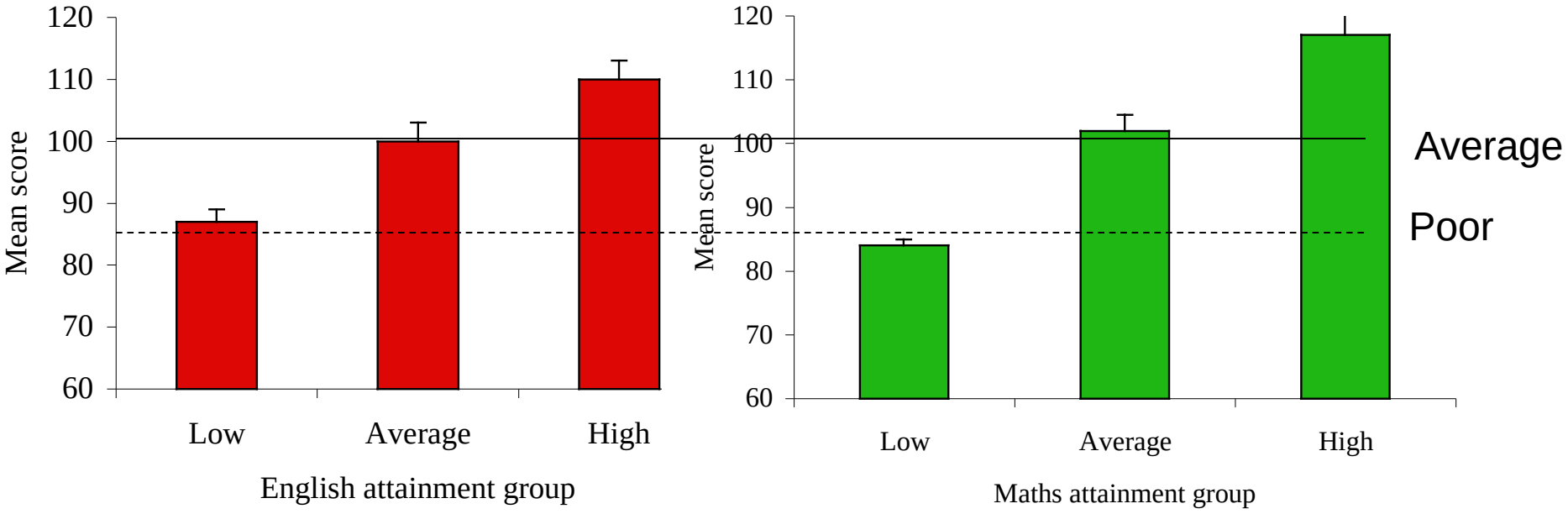
- Assessed within 6 weeks of school entry at 4 years
- Working memory skills were strongly associated baseline assessments of
  - reading
  - writing
  - mathematics

- Excellent predictors of Key Stage 1 maths and English levels, at 7 years.

Gathercole et al. (2003)

Assessing WM

Mean working memory scores as a function of English and maths attainment groups, schools data from 11-year olds



Gathercole et al. (2004)

Working memory as a longitudinal predictor of learning:

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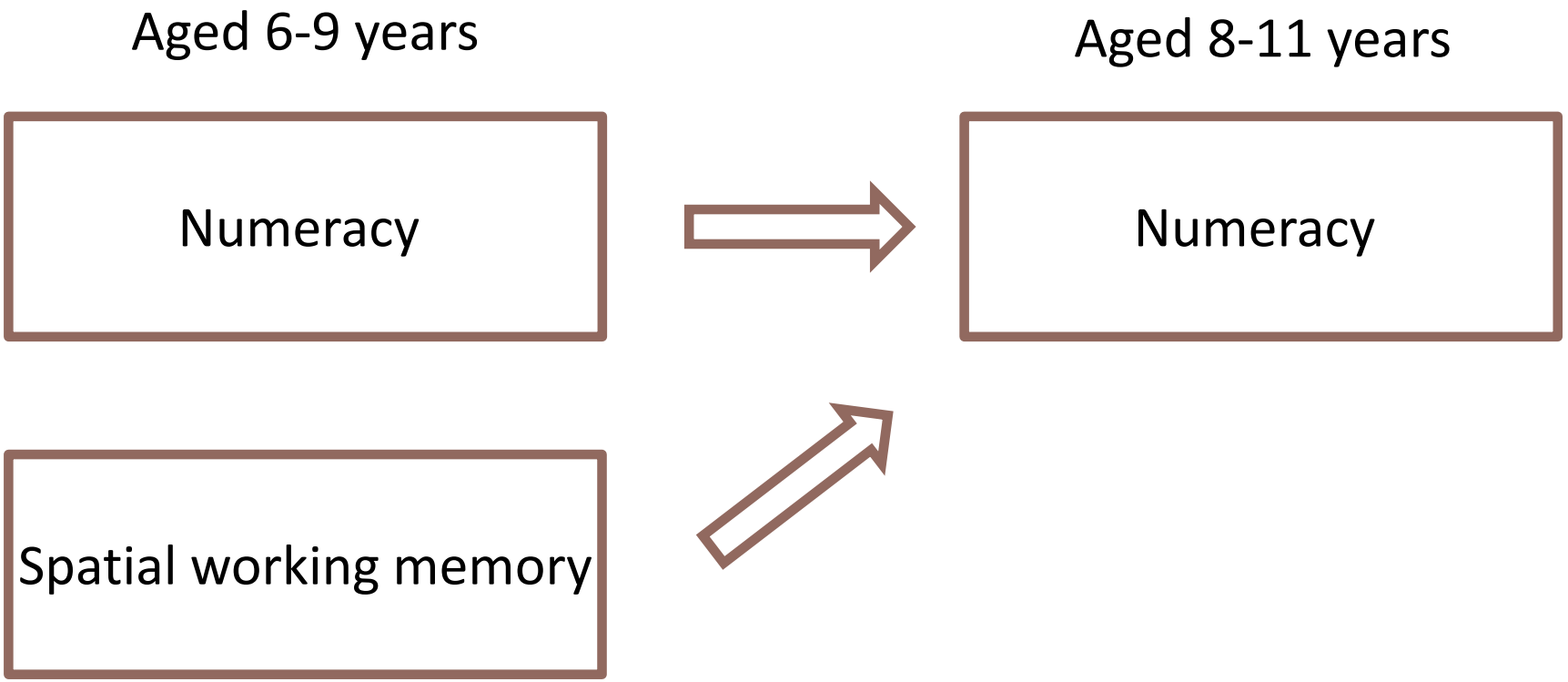

Astle, Woolgar & Scerif, Submitted

Why does working memory vary across individuals??

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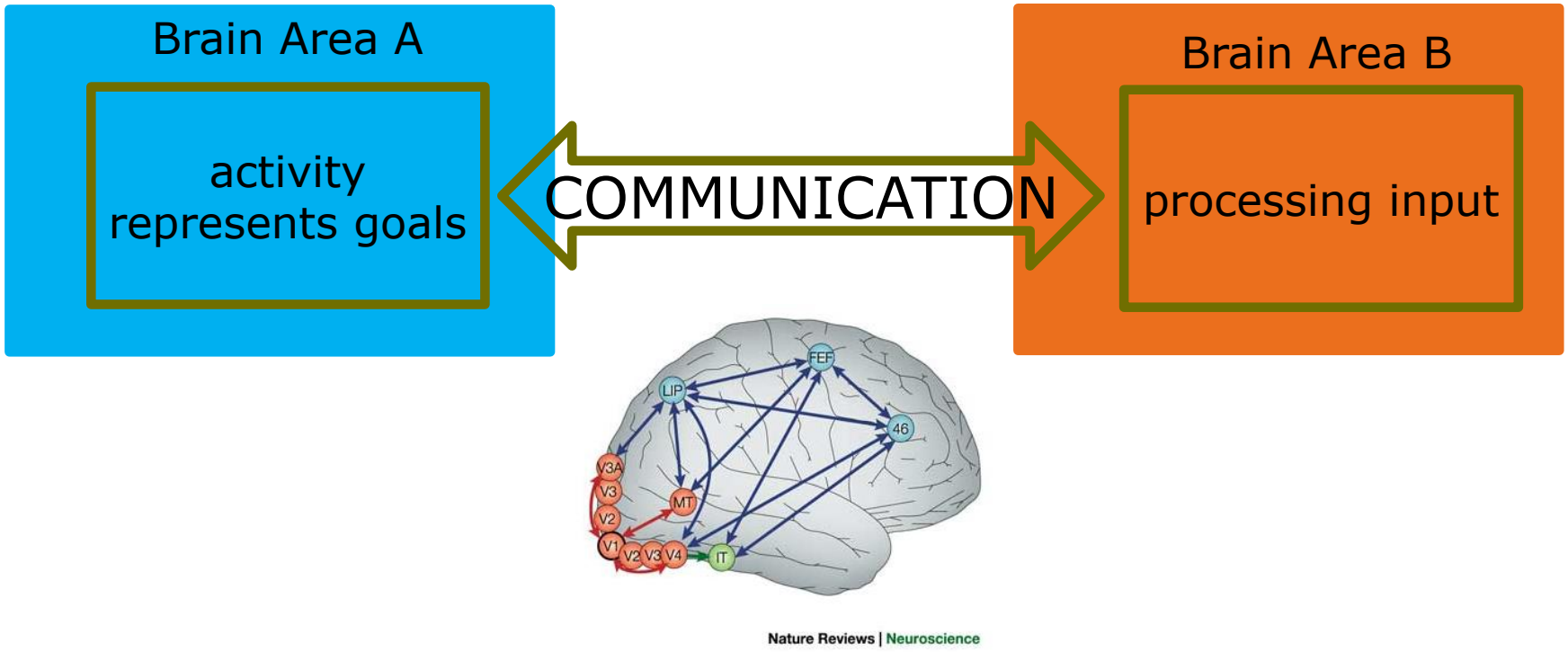
One aspect of brain activity that we focus on is **communication**



Are these linked to cognitive ability?

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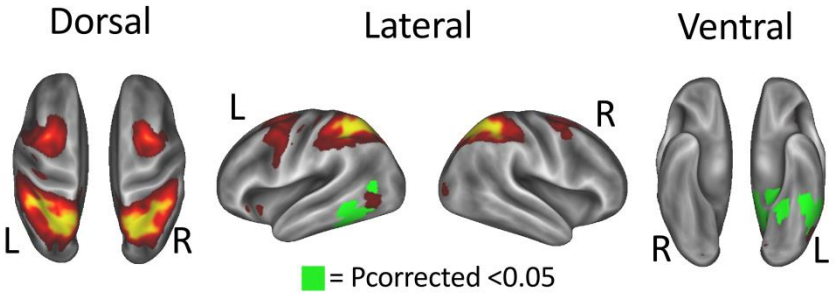
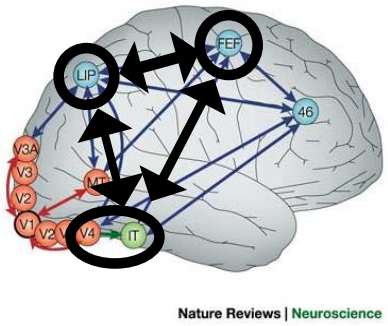
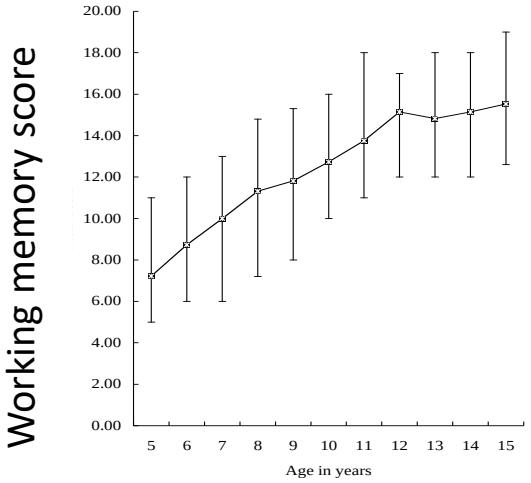
Individual differences across children







Barnes et al. 2015, Developmental Science

Characteristics of children with poor working memory

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- Poor academic progress

More than 80% of children with poor working memory fail to achieve expected levels of attainment in either reading or maths, typically both (Gathercole & Alloway, 2008)

Characteristics of children with poor working memory

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- Poor academic progress
- Reserved in groups

Ross (6 years) is a reserved and quiet child who tends not to volunteer responses and rarely answers direct questions, particularly in the whole-class situation. He sometimes becomes more vocal when working in small groups although he isn't necessarily discussing the task in hand.

Characteristics of children with poor working memory

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- Poor academic progress
- Reserved in groups
- Difficulties in following instructions

"Put your sheets on the green table, arrow cards in the packet, put your pencil away and come and sit on the carpet."

John (6 years) moved his sheets as requested, but failed to do anything else. When he realized that the rest of the class was seated on the carpet, he went and joined them, leaving his arrow cards and pencil on the table.

Characteristics of children with poor working memory

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- Poor academic progress
- Reserved in groups
- Difficulties in following instructions
- Loses track in complex tasks and has difficulty keeping place

When the teacher wrote on the board Monday 11th November and, underneath, The Market, which was the title of the piece of work, Nathan lost his place in the laborious attempt to copy the words down letter by letter, writing moNemarket.

Characteristics of children with poor working memory

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- Poor academic progress
- Reserved in groups
- Difficulties in following instructions
- Loses track in complex tasks and has difficulty keeping track
- Teachers say: short attention span and highly distractible

"he's in a world of his own"
"he doesn't listen to a word I say"
"she's always day-dreaming"
"with him, it's in one ear and out of the other"

Recap:
II. Constraints on learning: working memory

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- Working Memory (WM) is a limited capacity resource that we use to hold in mind small amounts of information (and manipulate it) over brief periods of time
- WM is closely linked to many learning outcomes (e.g. level of literacy or maths attainment)
- WM develops gradually up until around 14 years of age
- WM is highly variable across children, even between children of the same age
- To provide an extreme example, poor working memory skills are associated with poor academic progress, difficulty keeping up in class and distractability
- These differences in WM have neurophysiological correlates

Is it possible to boost children's working memory skills?

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- Given the close relationship between working memory and academic attainment, many researchers have become interested in whether working memory can be trained
- There are now numerous commercially available working memory training programmes available
- Some of these are marketed to parents and educational professionals
- But it is important to test the impressive claims of these products with independent research studies

Can you train working memory?

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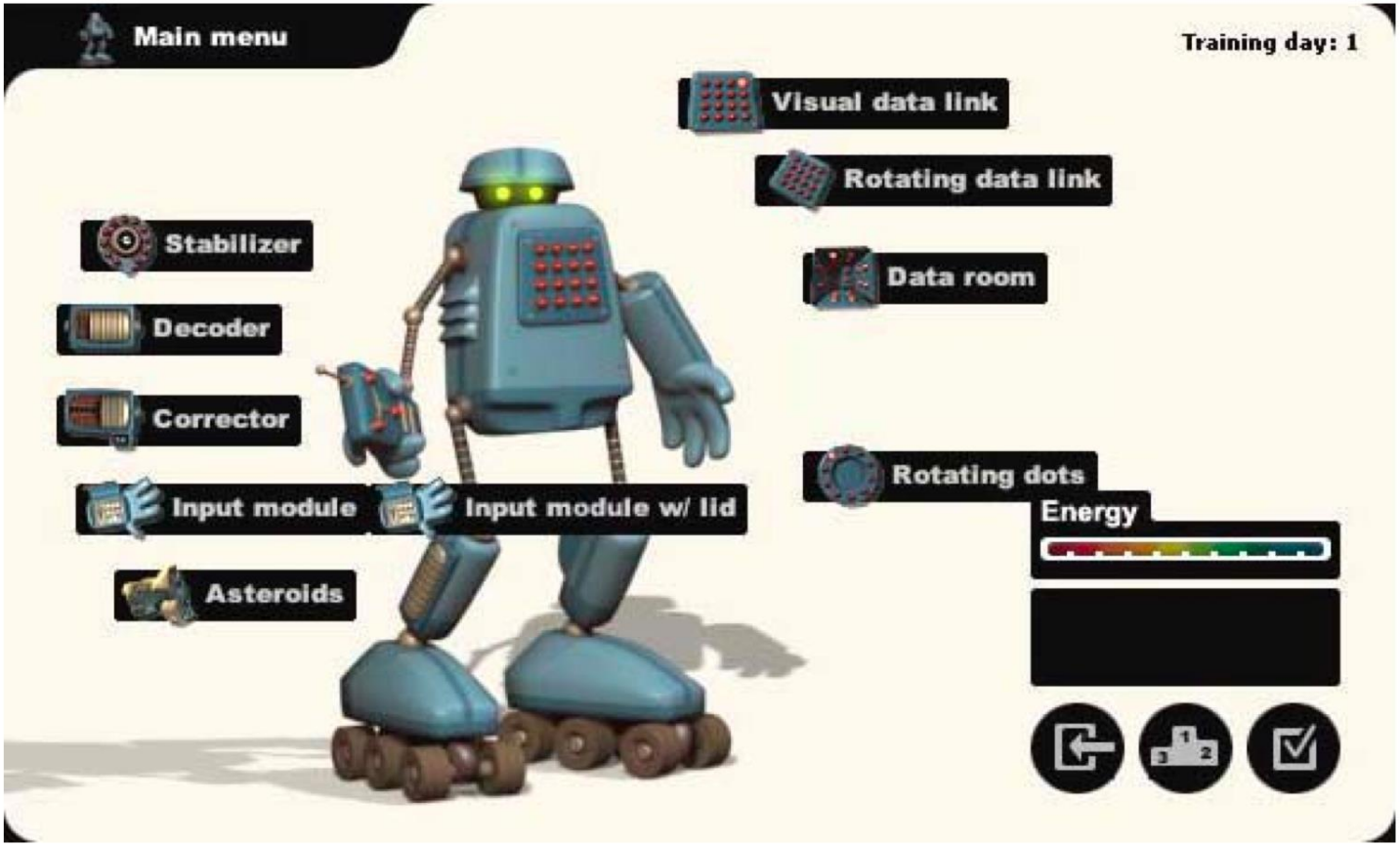

Can you train working memory?

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Screenshots from two training tasks

Can you train working memory?

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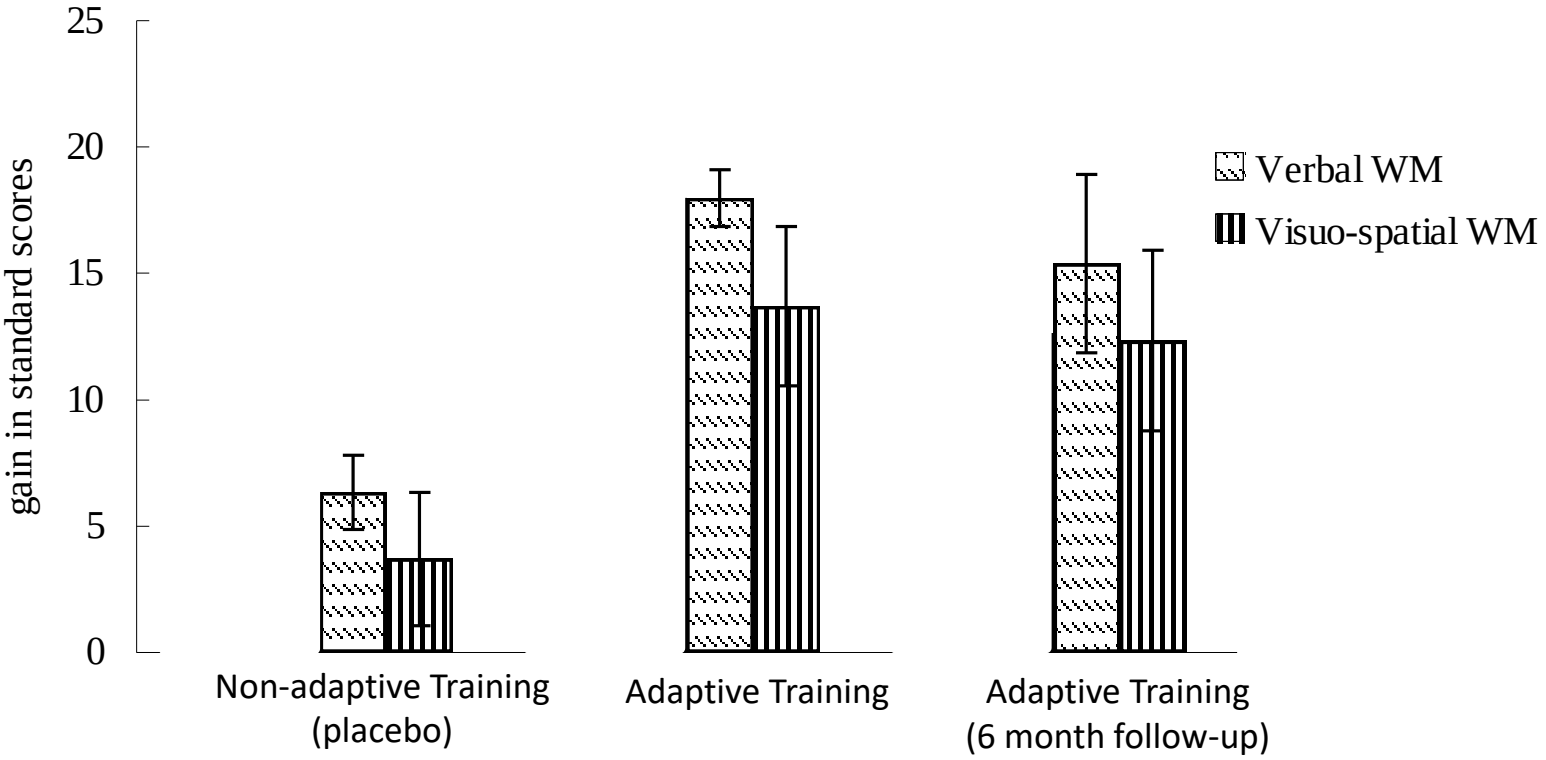
Children with low working memory



Can you train working memory?

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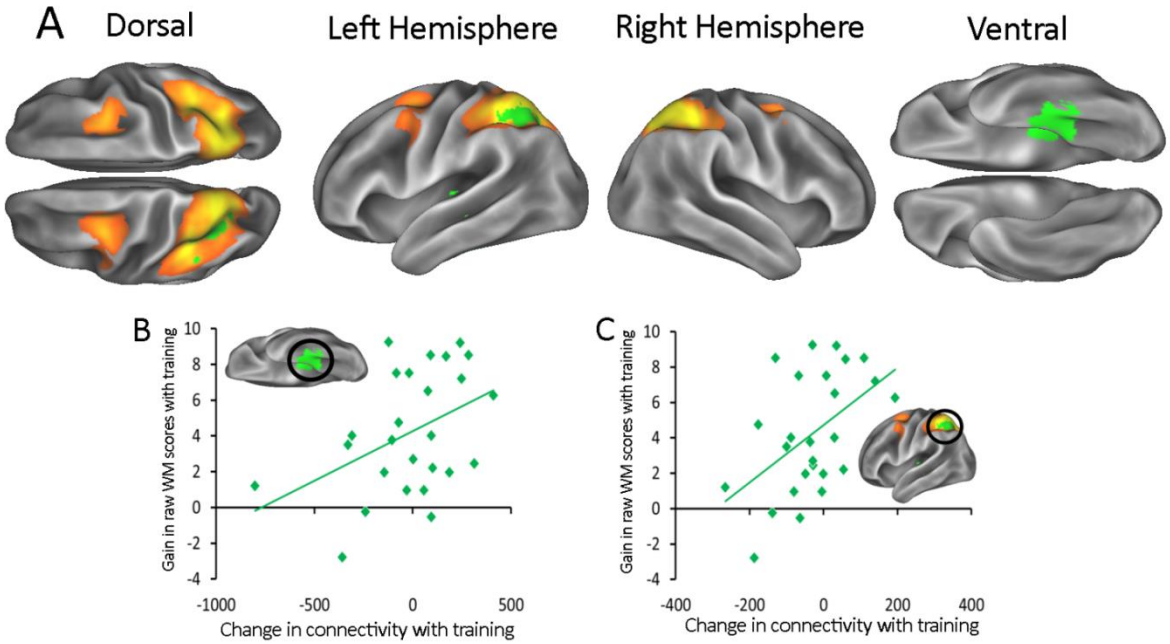
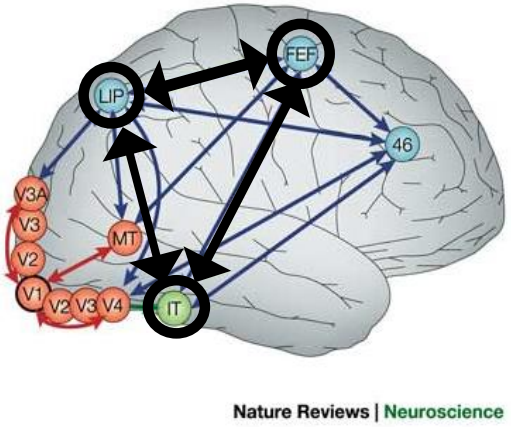
Does the training impact on brain physiology?





Astle et al. (2015) Journal of Neuroscience

Can you train working memory?

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RCT in low WM children (Dunning et al., 2013):

Improvements persisted 12 months after training

But:

- no changes in classroom activities taxing WM including following instructions
- no improvements in even maths or reading, even after 12 months

Original Investigation

ONLINE ONLY FREE

May 2, 2016

Academic Outcomes 2 Years After Working Memory Training for Children With Low Working Memory

A Randomized Clinical Trial

Gehan Roberts, MPH, PhD[1]; Jon Quach, PhD[2]; Megan Spencer-Smith, PhD[3]; et al

» Author Affiliations | Article Information

JAMA Pediatr. 2016;170(5):e154568. doi:10.1001/jamapediatrics.2015.4568

Overview

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- Variability in cognitive abilities – like working memory – will greatly impact upon an individuals capacity to engage with new material in any learning setting.
- A child's working memory capacity is an excellent predictor of how well they will do in class
- Working memory capacity is highly variable amongst children of the same age, and these differences are associated with difference in brain physiology
- There have been various attempts to train working memory, and very strong claims made about its wider benefits. However, evidence for wider transfer is weak (at best).

A better approach to supporting working memory in class is to consider how we structure learning to reduce needless memory demands – join us in the break out for a discussion on this.

III. Constraints on learning: long-term memory

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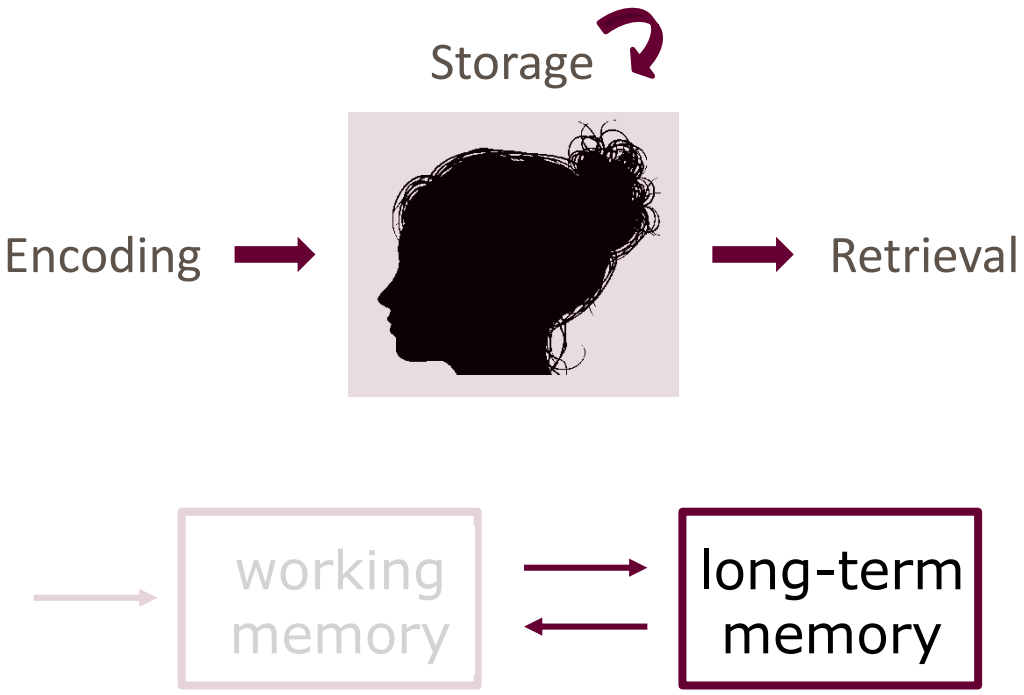

Learning of new information

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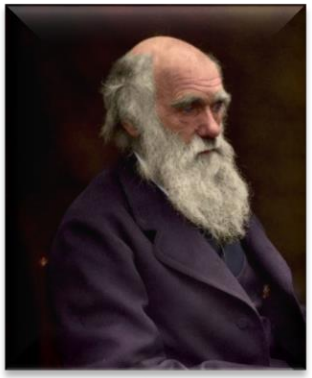
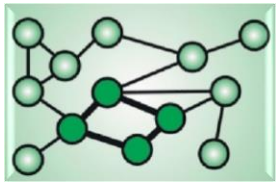


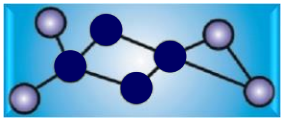
Encoding

Neocortex
(semantic)



slow, long-term store

Hippocampus
(episodic)



fast, initial store

binding

McClelland et al. (1995). Psychological Review

Learning of new information

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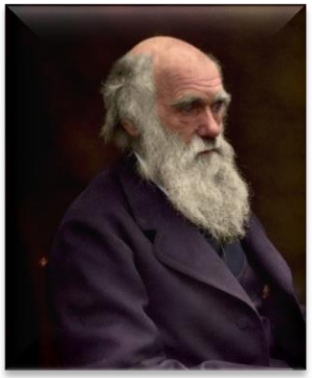

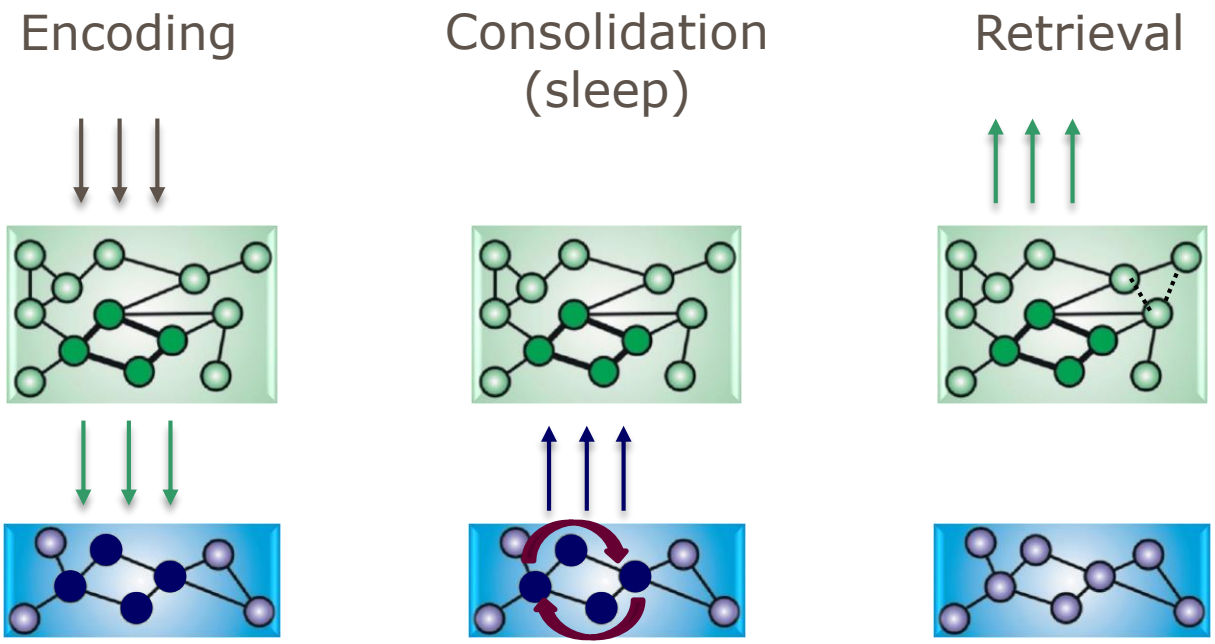

Feld, G.B & Born J (2017). Current Opinion in Neurobiology

Learning of new information

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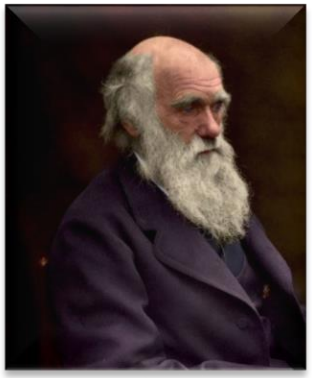

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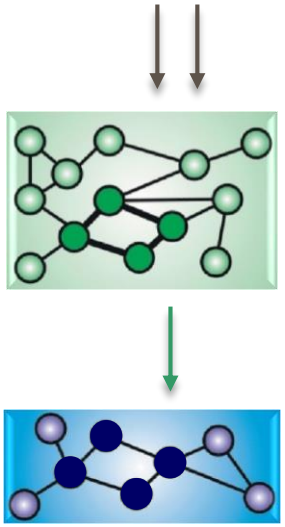
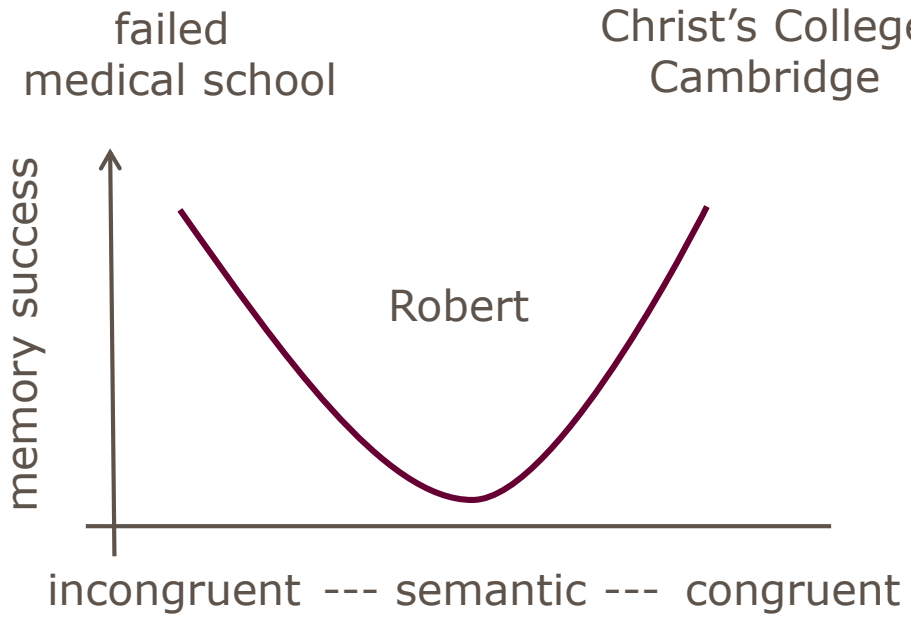


Neocortex
(semantic)

Hippocampus
(episodic)



Greve et al (2017). Journal of Memory and Language

Encoding: Levels of Processing

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Storage

Encoding →  → Retrieval

depth of processing

perception (physical) — CAT

phonemic (sound) — Bike, house

semantic (meaning) — mouse, Dog, shop

Storage principle

Storage

Encoding →  → Retrieval

CAT
Bike
house
mouse
Dog
shop

Storage principle

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Storage

Encoding →  → Retrieval

Rehearsal
Maintenance
Elaborative
Organisation
Chunking

CAT
Bike
house
mouse
Dog
shop

CAT
Bike
house

mouse
Dog
shop

Storage principle

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Storage

Encoding →  → Retrieval

Rehearsal
Maintenance
Elaborative
Organisation
Chunking
Semantic

CAT
Bike
house
mouse
Dog
shop

CAT
mouse
Dog

house
Shop

Bike

Retrieval principle

Cue-dependency

CAT

Bi_e

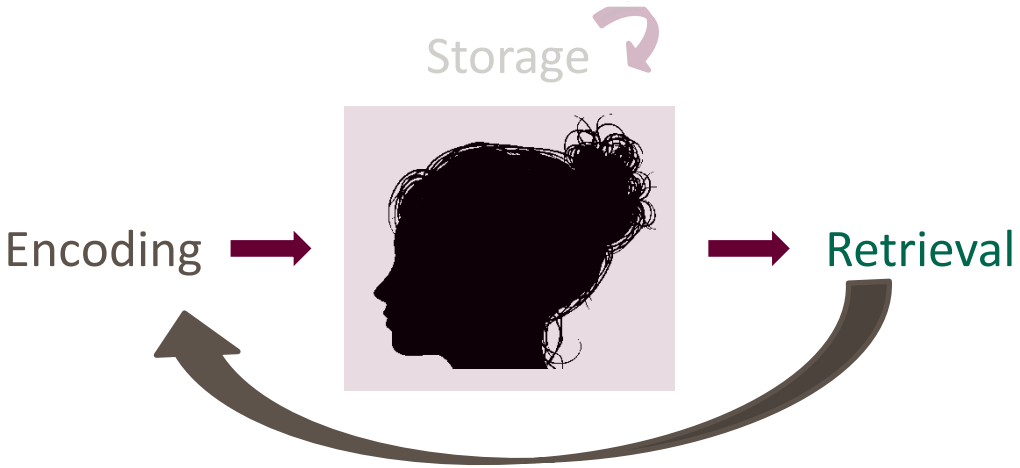
?

_ouse

Dog

?

Retrieval principle



Cue-dependency

Encoding specificity

CAT

Bi_e

?

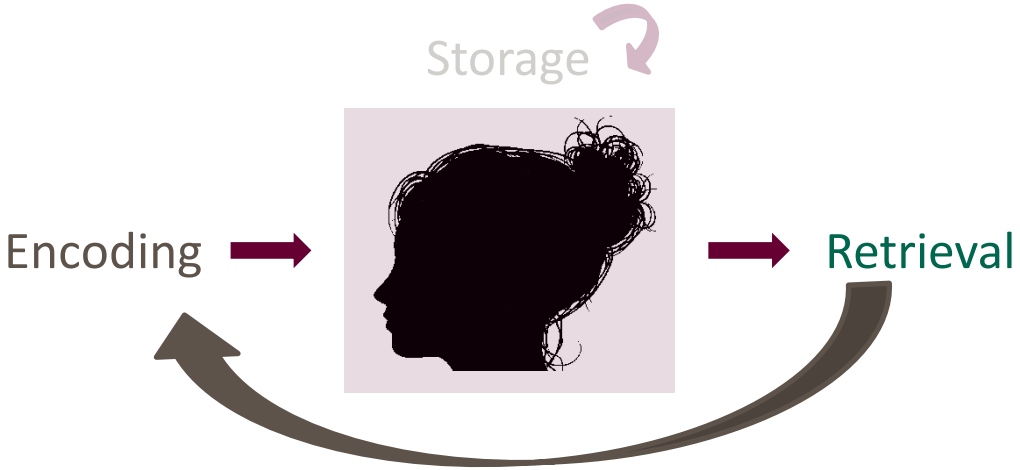
rhymes with mop?

_ouse

Dog

?

Retrieval principle



Cue-dependency

Encoding specificity

Context specificity

CAT
Bi_e
?

_ouse
Dog
?

Godden & Baddeley (1975)

Memory processes and principles

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Storage

Encoding →  → Retrieval

Level of Processing

Cue-dependency
Encoding specificity
Context dependency

Rehearsal
Organization

IV. Learning techniques

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1. Spaced Practice

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Study the material in several sessions spread out over a long period of time, rather than repeatedly learn material in a short period of time.

Studying five hours spread out over two weeks is much more effective than five hours all at once.

2. Interleaving

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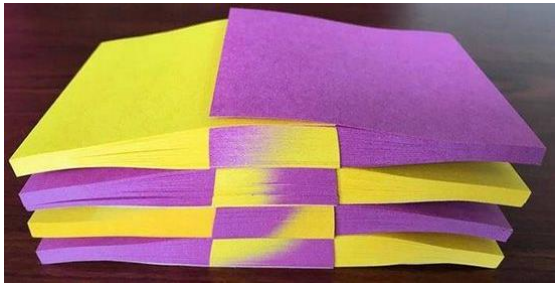
Instead of practicing one skill at a time ("AAABBBCCC"), interleaving mixes practice on several related skills together (for example, "ABCABCABC").



switch between ideas during a study session
go back over the ideas again in different orders

3. Retrieval Practice

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Devote some of the learning period to retrieving the to-be-remembered information through testing it with proper feedback.

answering questions is strengthening memory
active learning > passive learning

4. Elaboration

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Use strategies that enhance the information of the learning material and increases their relation to other information the learner already knows.

encoding the original content
in a different but related way

5. Curiosity

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Gruber et al. (2014). Neuron

6. Intention to learn

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Mandler (1967)

7. Interference

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Interference occurs when old and new information overlap, which has a negative influence on remembering old or learning the new information.

Underwood & Postman (1960). Psychological Review

8. Sleep

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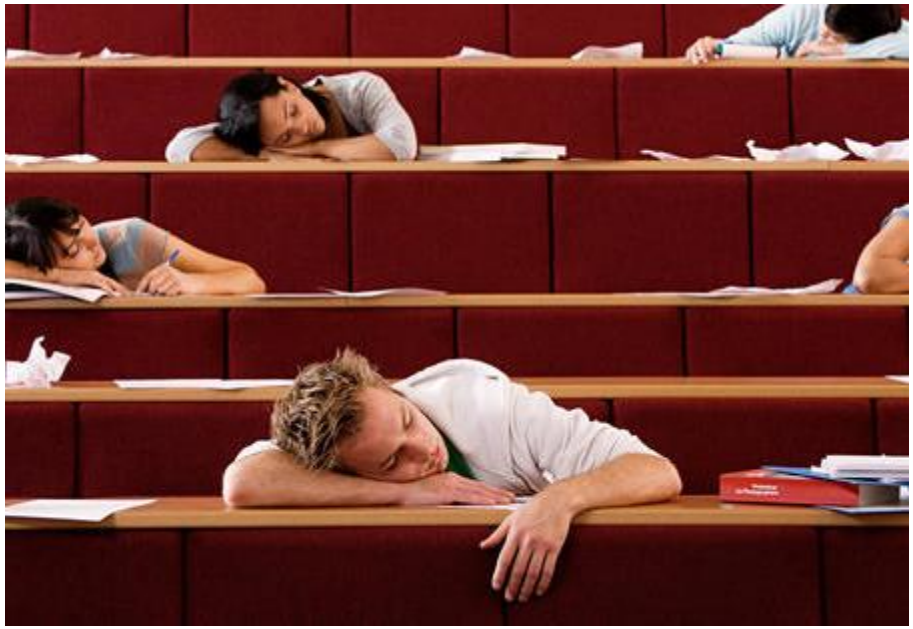

Diekelmann & Born. (2010). Nature Review

Recap:
Long term memory in the classroom

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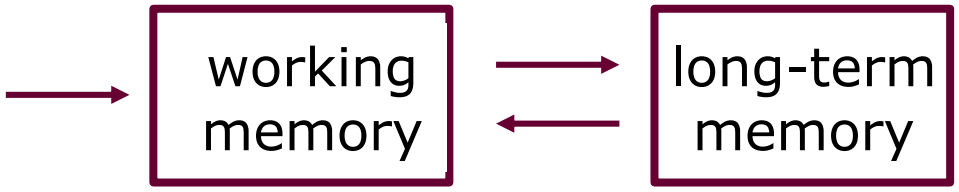
- Distinct Episodic and Semantic memory systems
- Distinct memory processes: encoding, consolidation and retrieval
- Learning techniques that benefit long term memories

Summary



Semantic

Episodic

Join us in our breakout session to discuss ideas for:

1) Reducing working memory load in the classroom
2) Learning techniques for supporting good long-term memory

Thank you !

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