The resilient brain: cognition and aging

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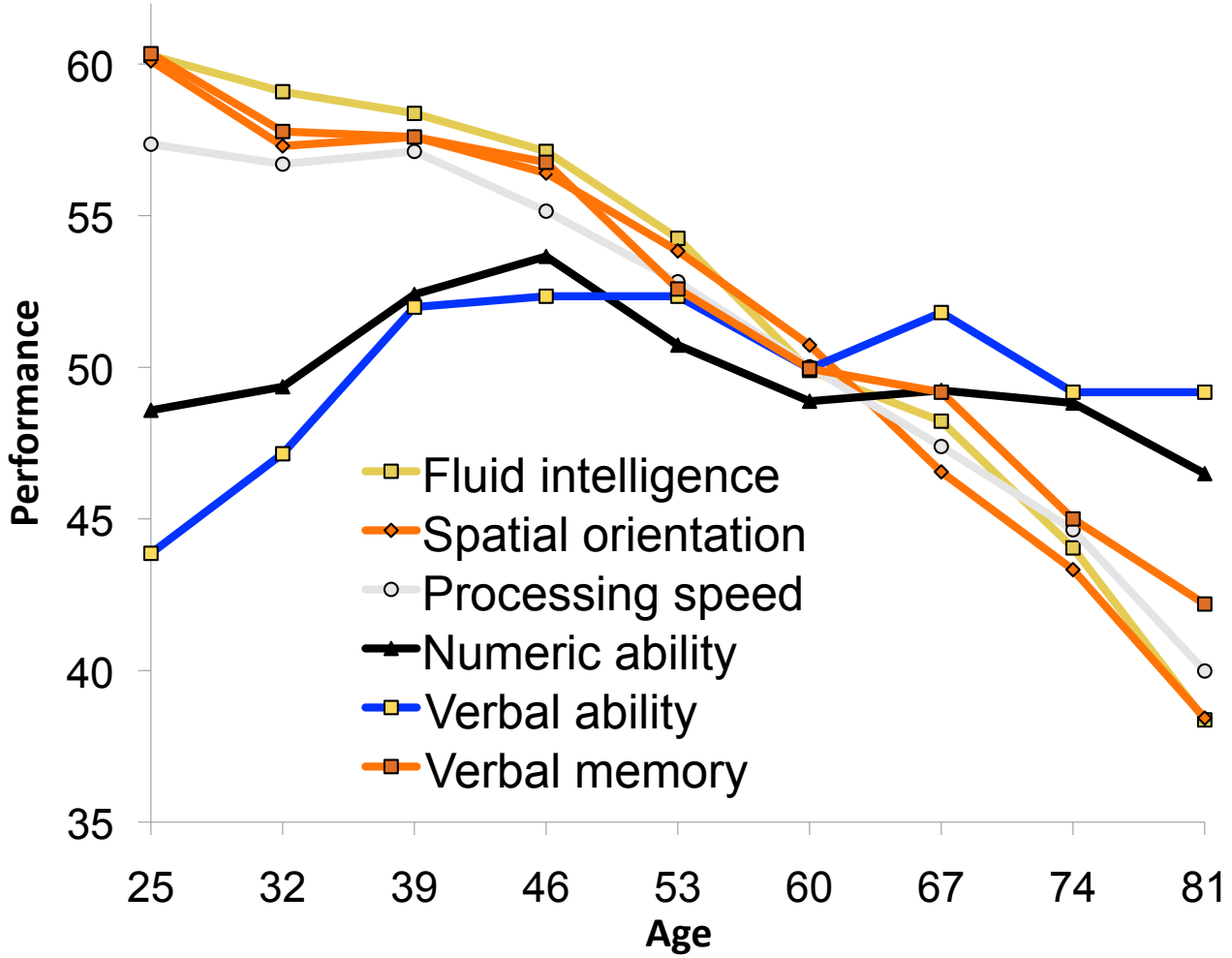
Structure of talk

- Discuss **variability** in cognitive and brain changes across the lifespan. Variability across individuals, cognitive functions and brain regions
- Argue that **brain health** is key to preserved cognition
- Show that brain is **flexible and adaptive**
- Ask whether we can **enhance** the adaptive properties of the brain and **preserve cognitive health**?

AGING: THE SERIOUS SIDE

Changes in cognition

Variation in age-related cognitive changes

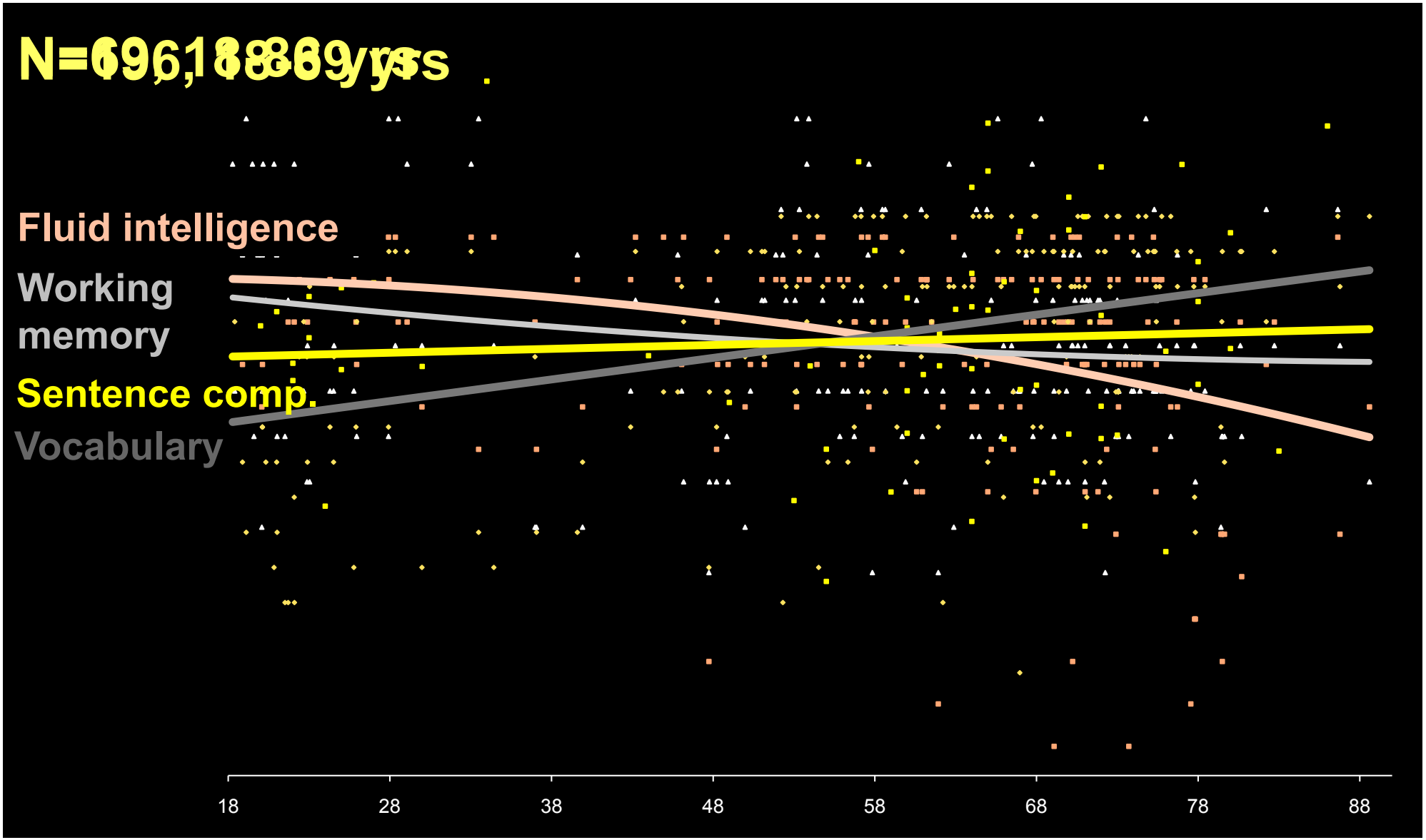


Hedden & Gabrieli, 2004

Not everything goes

The hallmark of cognitive change across the adult life-span is its variability

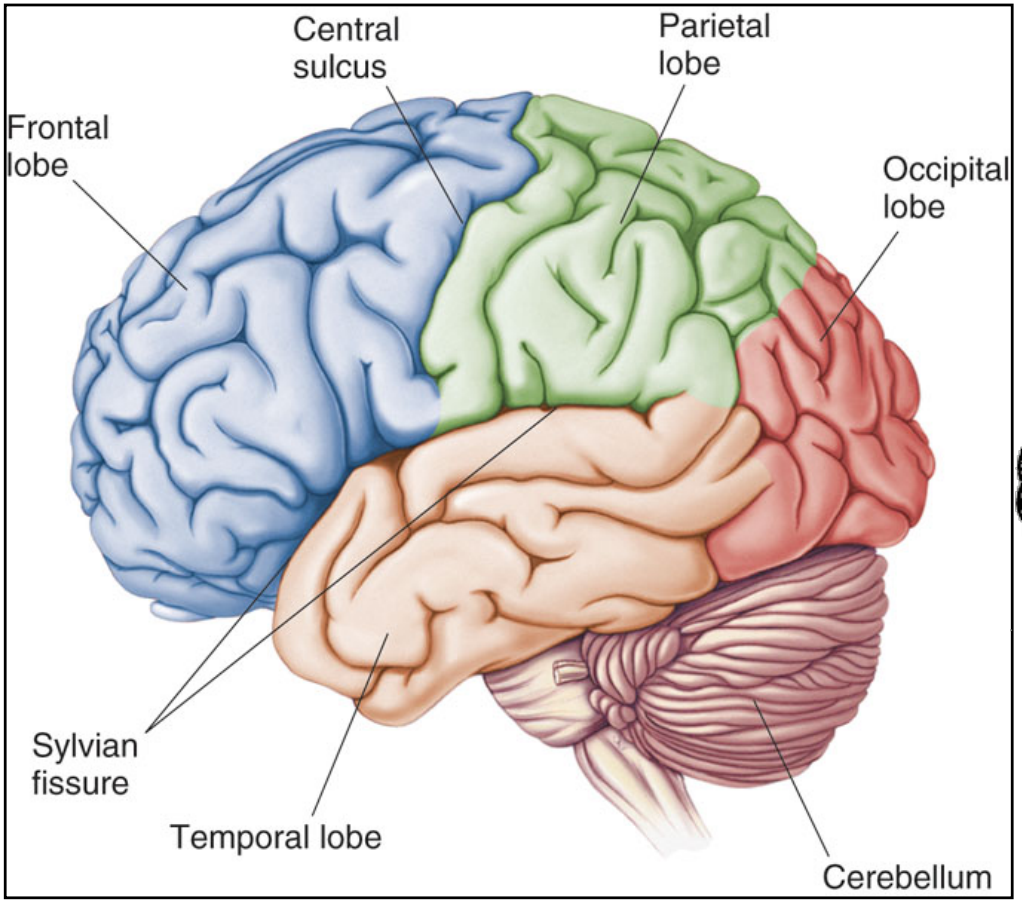
Cognition : Variability across individuals

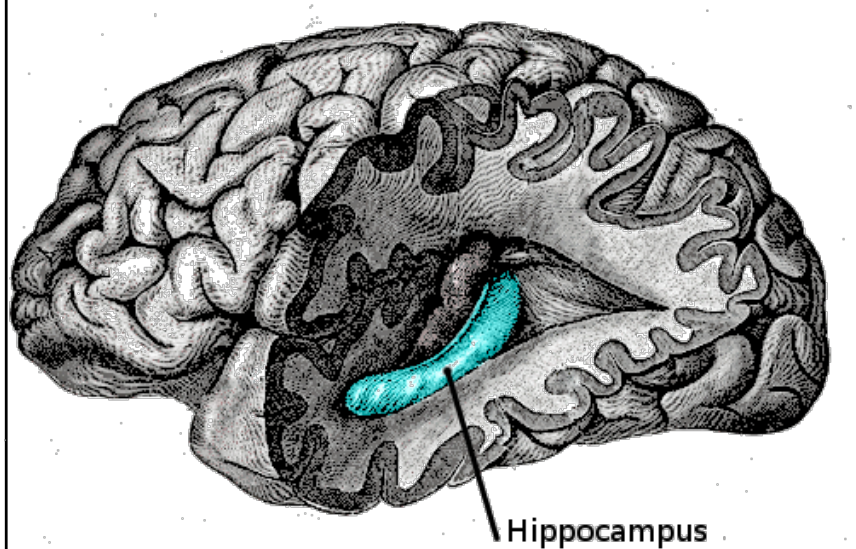


THE BRAIN CHANGES WITH AGE..

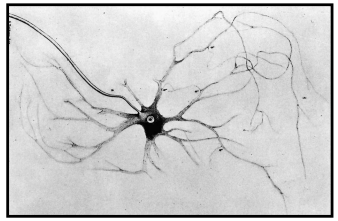
Quite extensively

BRAIN PREAMBLE

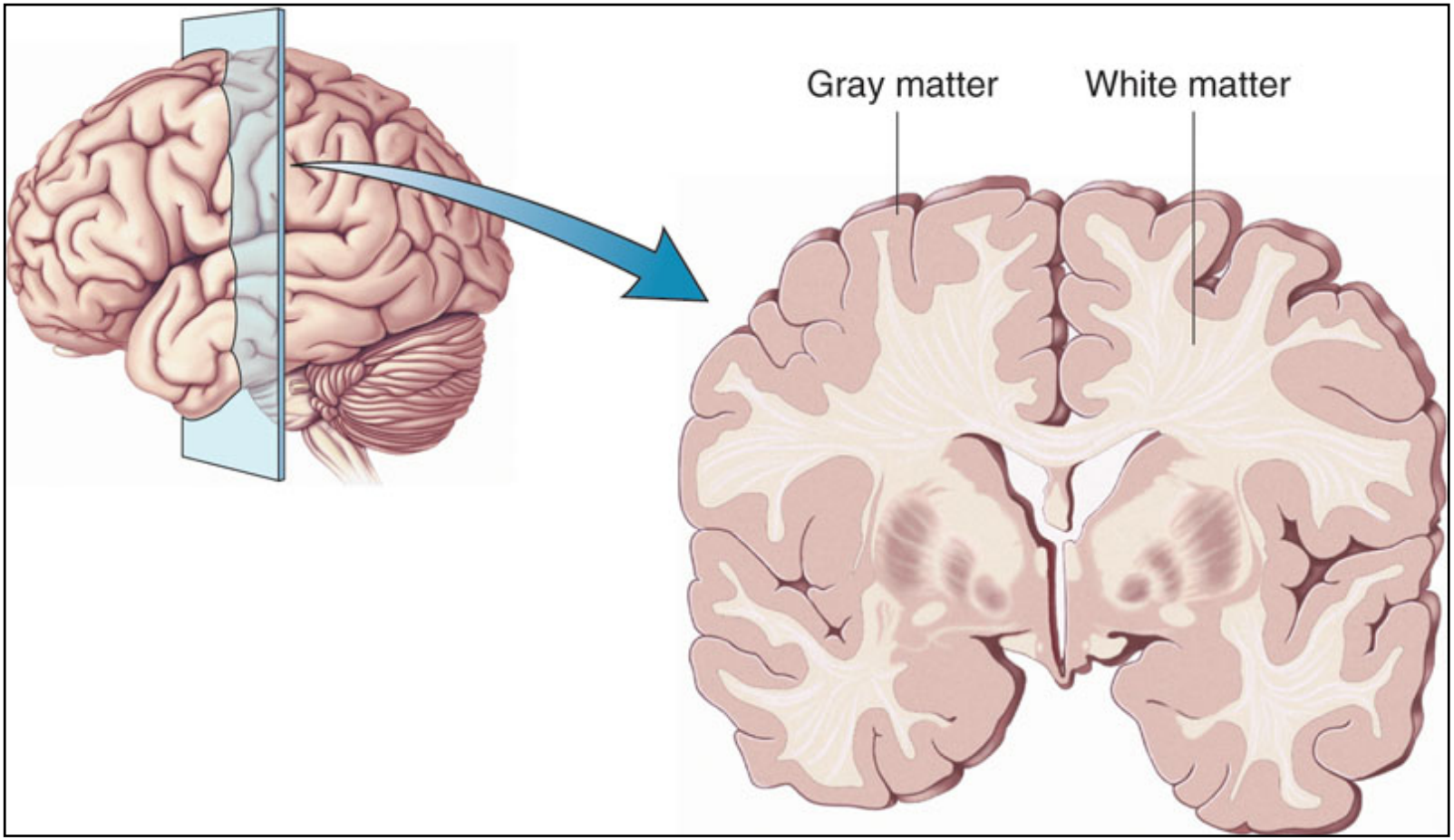




Grey matter = neurons/cells



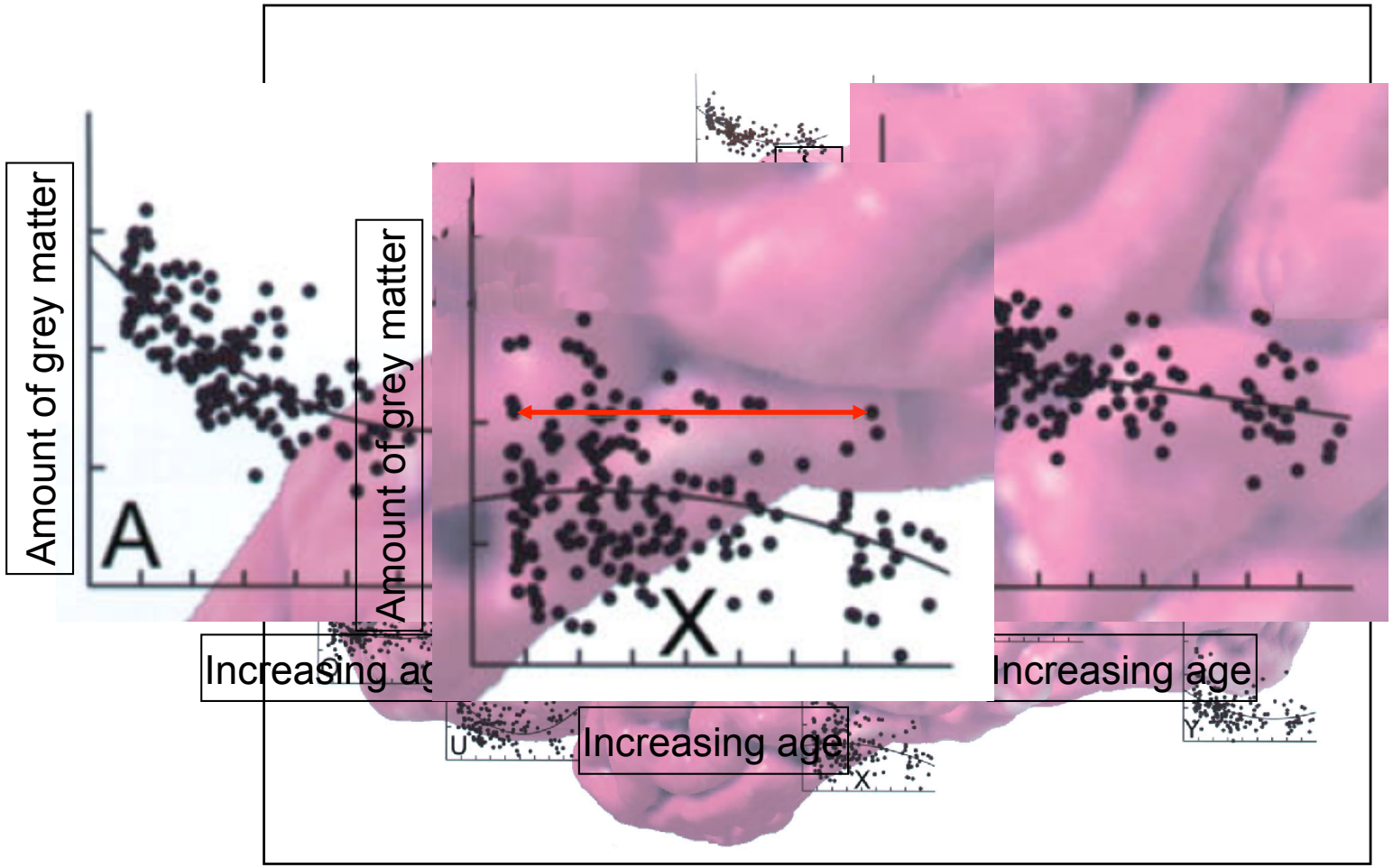
White matter = connecting tracts between concentrations of neurons



Age-related changes in brain structure

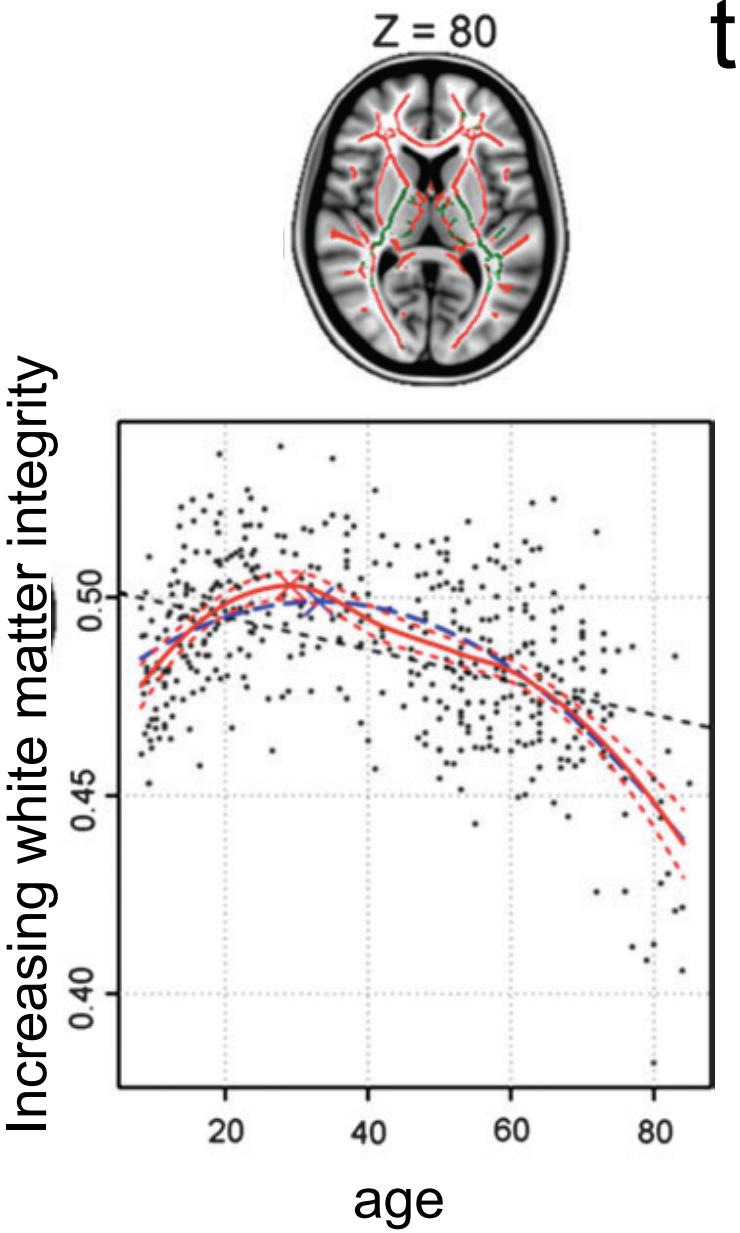
19
23
27
30
34
49
55
58
60
64
68
72
76
80
83
86

Variability in changes in grey matter



Sowell et al, 2003

Variability in changes in white matter tracts



i) Huge individual variability at all ages

ii) White matter tracts start to decline **as early as age 30;** aging is not something that happens late in life – it's a maturational process that occurs from early adulthood

Westlye et al, 2010

Summary: age-related changes

Variability

- Huge variability across individuals, cognitive functions and brain regions

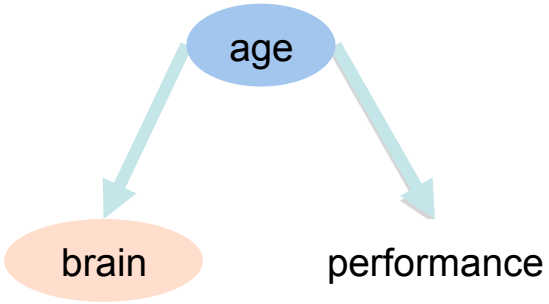
- **Change is continuous across the adult life-span**

RELATIONSHIP BETWEEN BRAIN CHANGES AND COGNITIVE CHANGES

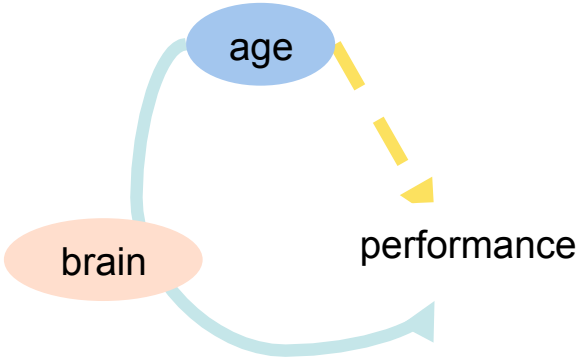
Relationship between brain changes and cognitive changes

20 yr old 85 yr old

Dominant view… aging is associated with an inevitable decline in both performance and brain measures



Recent view … **brain changes** rather than chronological age accounts for declines in cognitive performance.



Smaller effect of age when brain health taken into account

Brain health is what matters most

Striking example of this idea

Research report: *No disease in the brain of a 115-year-old woman*.

2 years before her death:
Cognitive performance was above average for healthy adults of 60-75 years.

Postmortem analysis revealed almost no pathology in her brain.

When the brain is healthy – whatever the age - cognitive deficits are less pronounced.


115 year old


30 year old control


76 year old AD patient

den Dunnen et al., 2008

A DIFFERENT TAKE ON AGING

Age-related changes in brain and cognition are not uniform, not inevitable and not immutable

A different take on aging

- Old view:
  - everything goes.
  - we might as well slide into inactive old age.
- Emerging views:
  - Age matters; but brain health matters more
  - Evidence that the brain remains flexible/adaptive across the life-span.
  - This flexibility helps to preserve cognitive functions.

Brain flexibility: Functional reorganisation

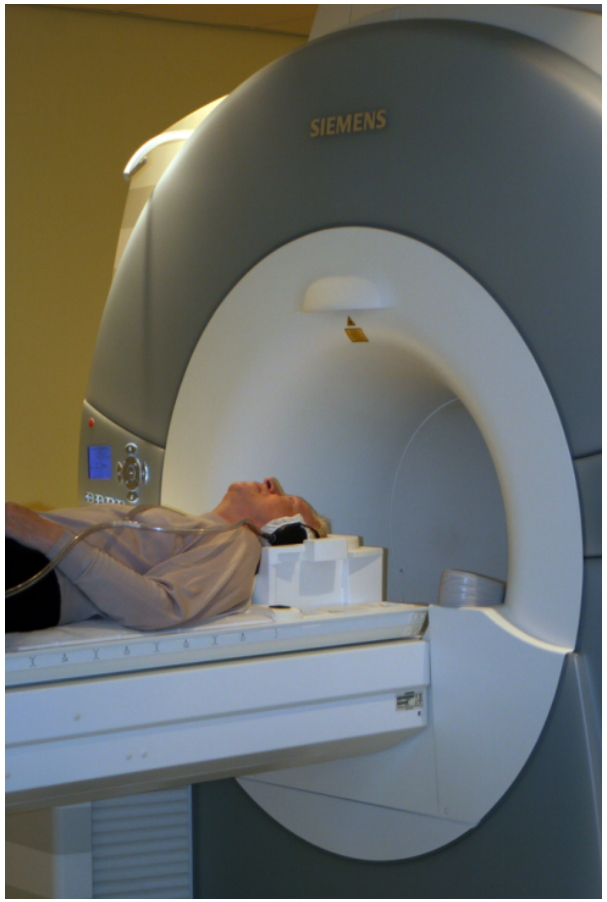
- Functional activity increases in response to age-related reductions in brain volume
- *And cognitive function is preserved*

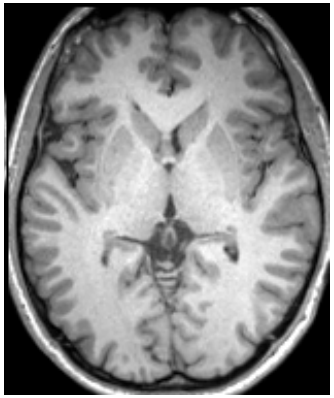
Shows brain structure and function

MRI

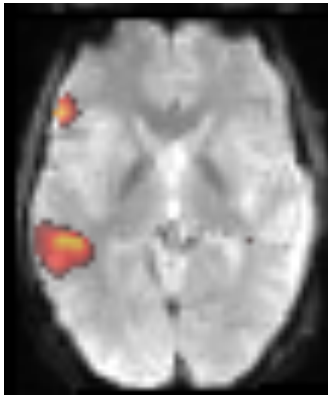
Non-invasive

Measures activity in the living brain





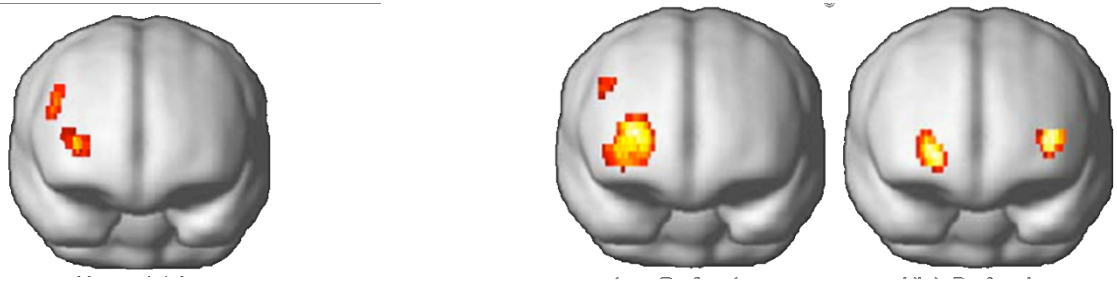
structure



Function/activity

Functional compensation with age

In many cognitive tasks, older adults who perform well on cognitive tasks produce **bilateral activation**



YOUNG ADULTS
Activity only in one hemisphere

OLDER ADULTS low-performers

OLDER ADULTS high-performers

Bilateral activity **compensates** for declines in brain structure with age

Cabeza, 2002

Functional compensation with age

- Typically seen in cognitive functions which generally decline [memory, attention]
- Also in cognitive functions that are preserved across the adult life-span [language comprehension]

Reflects particularly successful reorganisation/compensation

Functional compensation: *language comprehension*

Normal prose

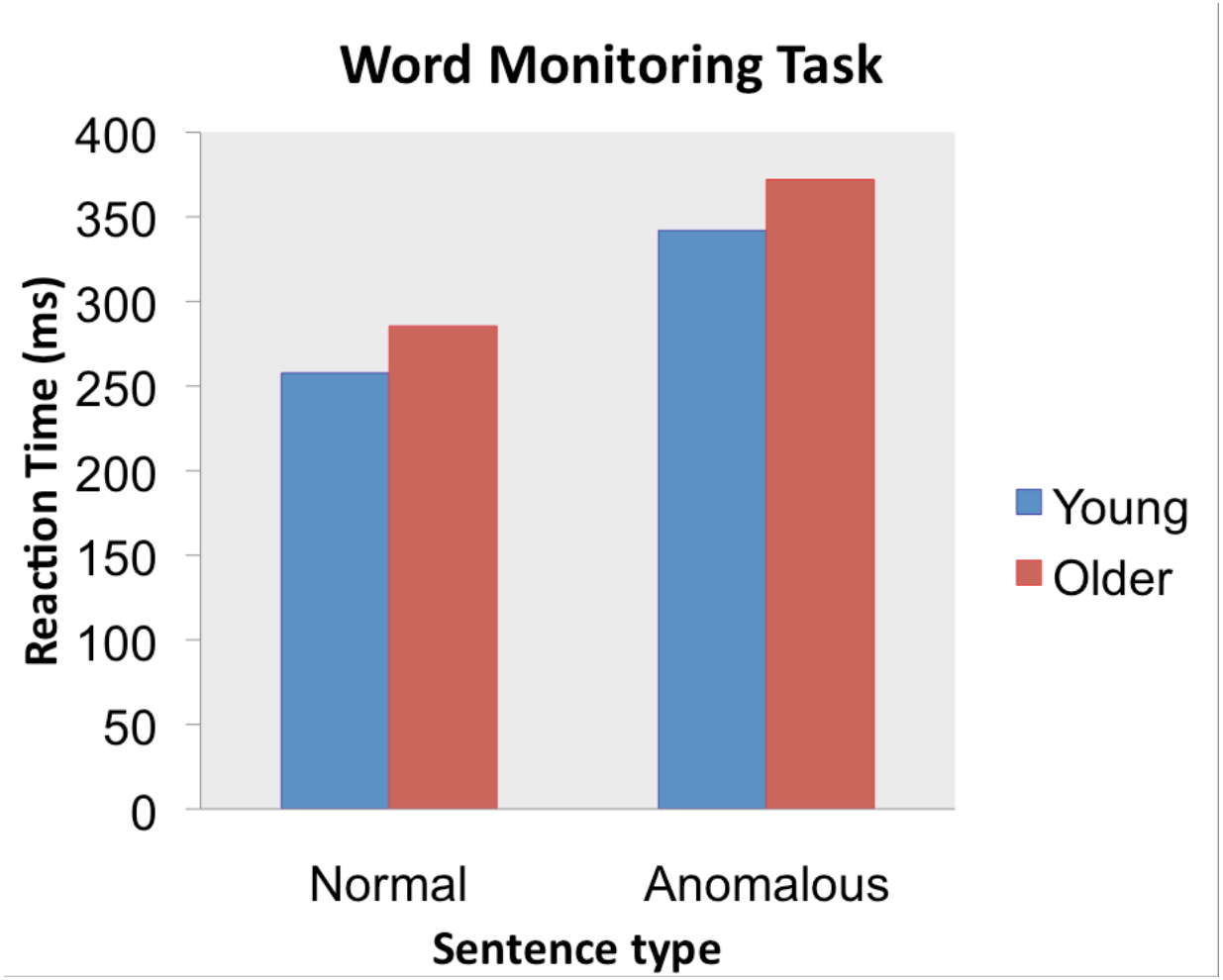
- *"He was trying to find the name of the TREE he planted last year "*

Anomalous prose (grammatical but meaningless)

- *"She was writing to use the college of a FISH she opened last week"*

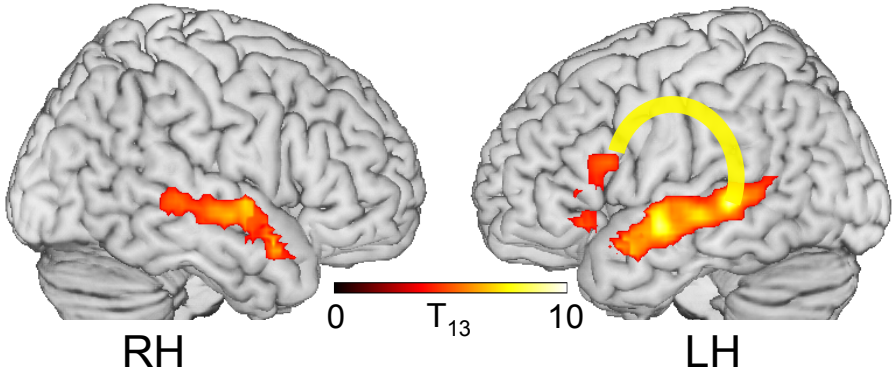
fMRI study; word monitoring task

Preserved performance in aging



Increased activation, preserved **syntax** and brain changes

Younger (19 – 34 yrs)



Tyler et al. (2010)

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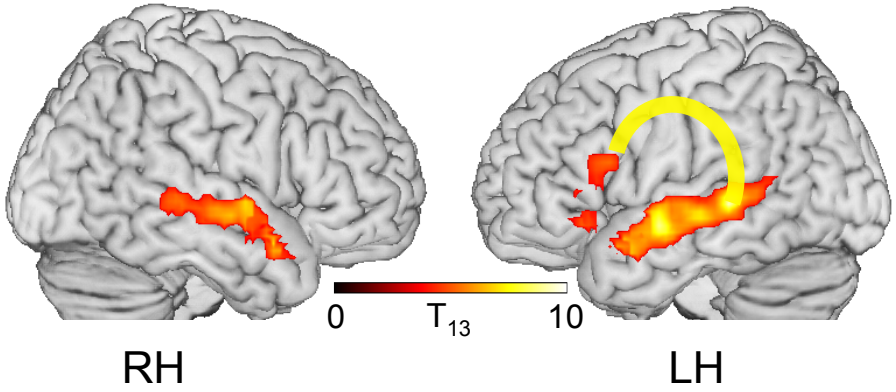
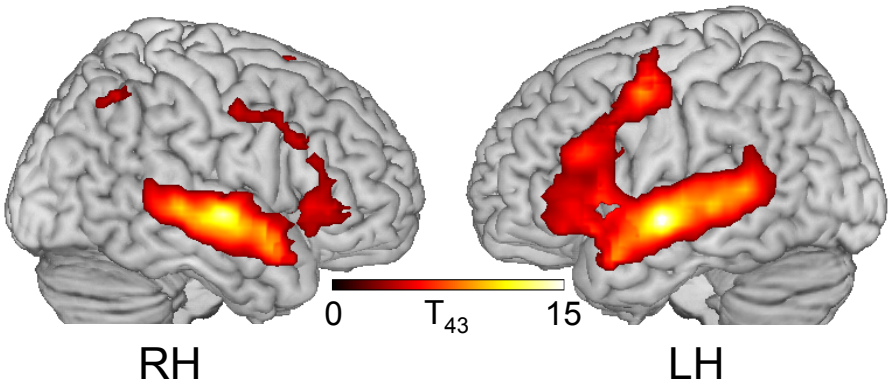


Older (49 – 86 yrs)



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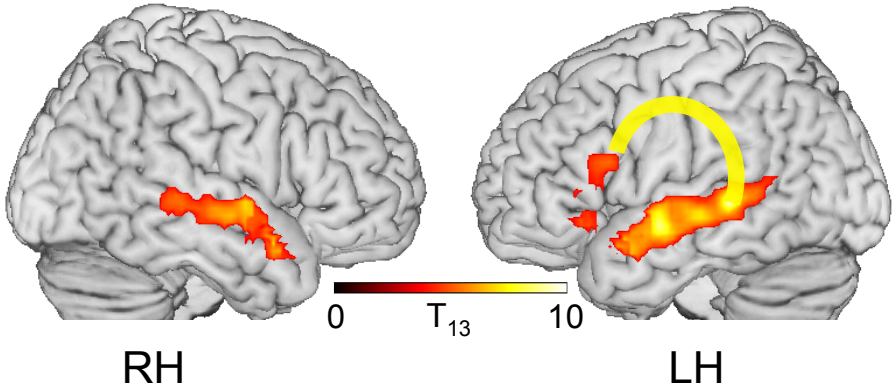

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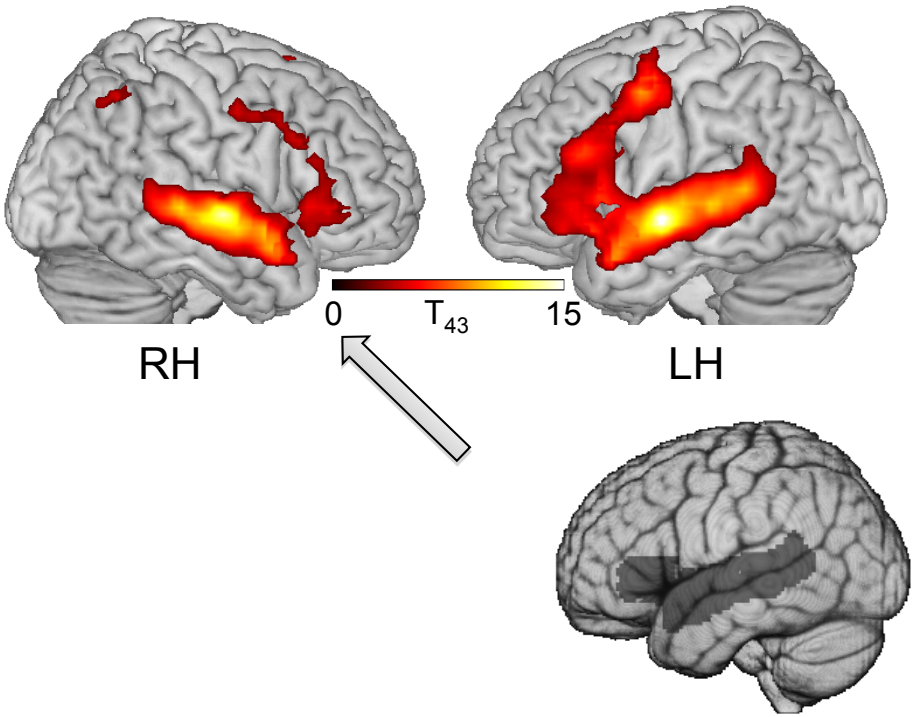


Less specialised system?
Less efficient?

Summary

- Age-related changes in brain structure do not inevitably lead to poor cognition.
- The brain – under some circumstances which we are trying to understand - is resilient and compensates for these changes and so maintains cognition.
- But not all cognitive functions are preserved in this way [word finding difficulties]
- Next sections suggest some other ways in which cognition can be preserved

Brain flexibility

External influences

1. Exercise
2. Cognitive training

Effect of exercise on brain and cognition

‘*It is exercise alone that supports the spirits and keeps the mind in vigor*”

Cicero

“To get back to my youth I would do anything in the world except take exercise, get up early or be respectable’

Oscar Wilde

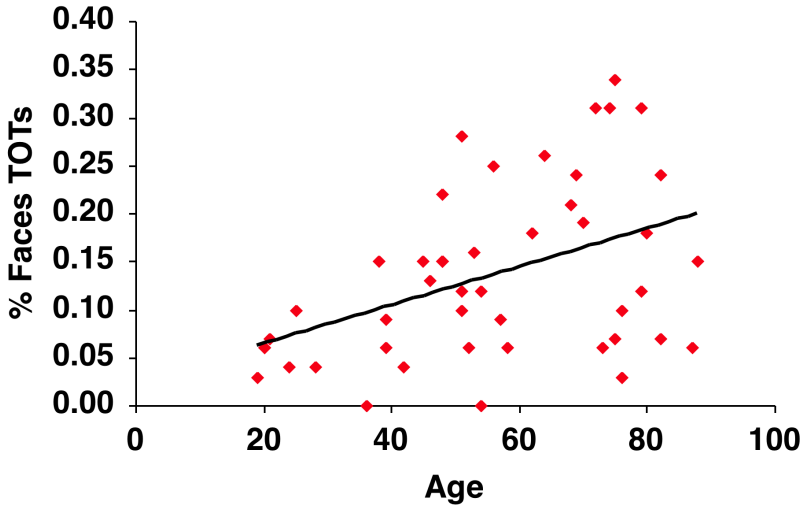
The Picture of Dorian Gray, 1891

Effect of exercise on **cognition**:

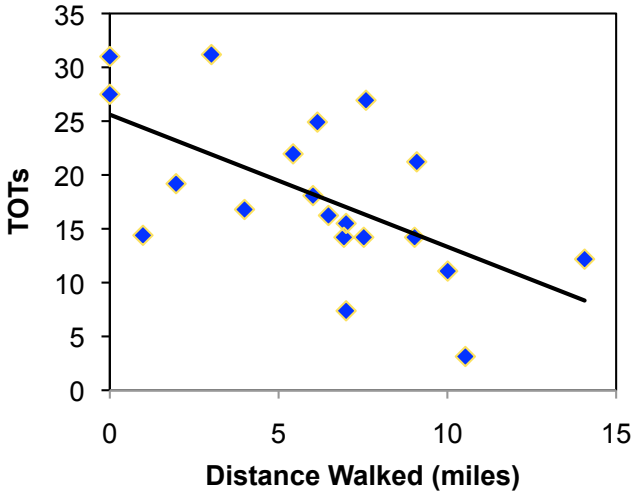
Word finding problems

Exercise reduces word finding problems

Word find problems
Increase with age



Word finding problems
Decrease with exercise



Shafto et al, 2007; Burke et al, 2011

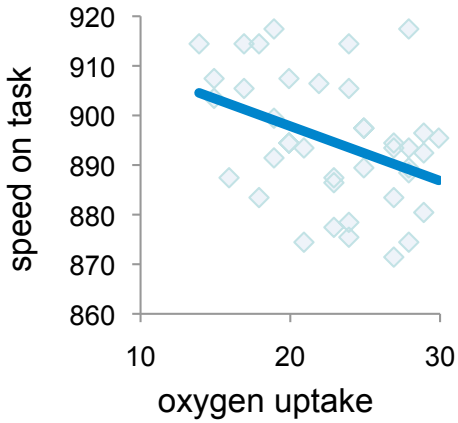
Effect of exercise on **brain**

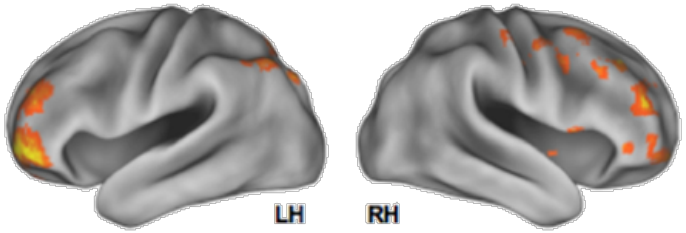
Cardiovascular fitness increases functional activation **and** improves cognition

Older adults who have better cardiovascular health (V02 uptake)…

…are faster on a demanding Stroop task

… and show increases in functional brain activity

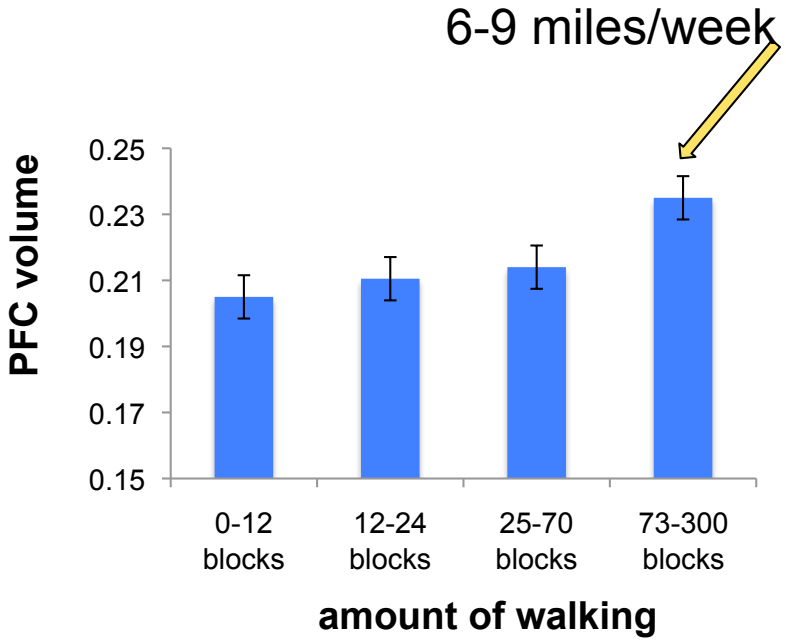




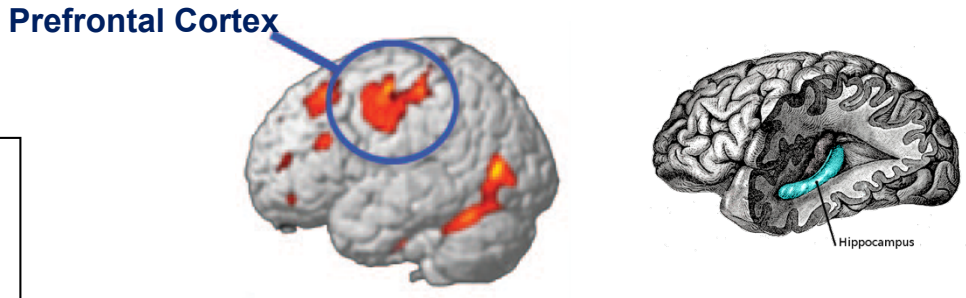
Prakash et al., *Frontiers in Neuro,* 2011

Cardiovascular fitness reduces losses in brain volume

Walking assessed at baseline:
6-9 miles/week of walking predicted greater GM volume 9 years later



Effects primarily in **prefrontal cortex and hippocampus,** critical for memory, executive control and learning.



Individuals with better cardiovascular fitness **less** likely to develop dementia

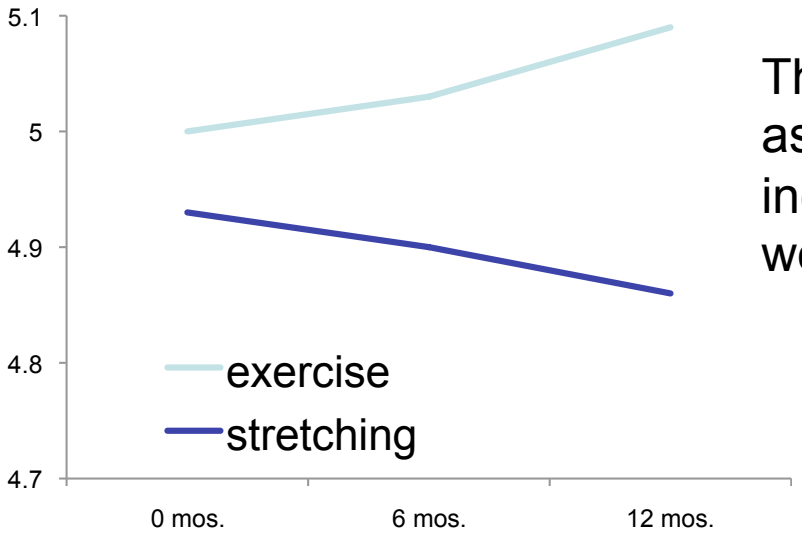
Erickson et al., *Neurology*, 2010

Cardiovascular fitness improves brain volumes AND cognition

Related study: aerobic exercise programme for 1 year

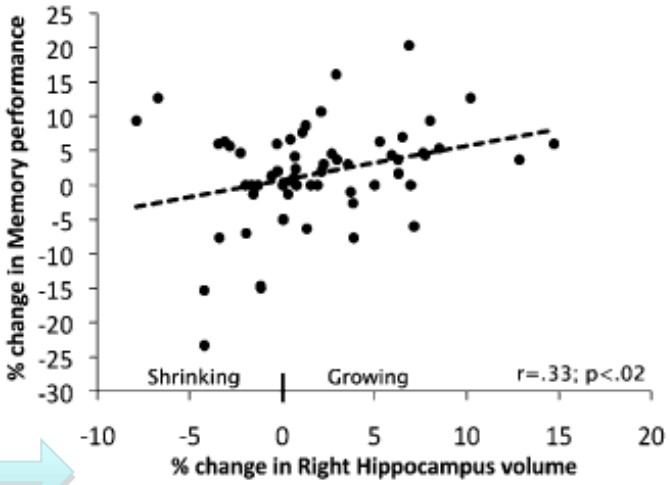
Hippocampus

Hippocampal volume



Active adults had increases in brain volume

This was associated with increases in working memory

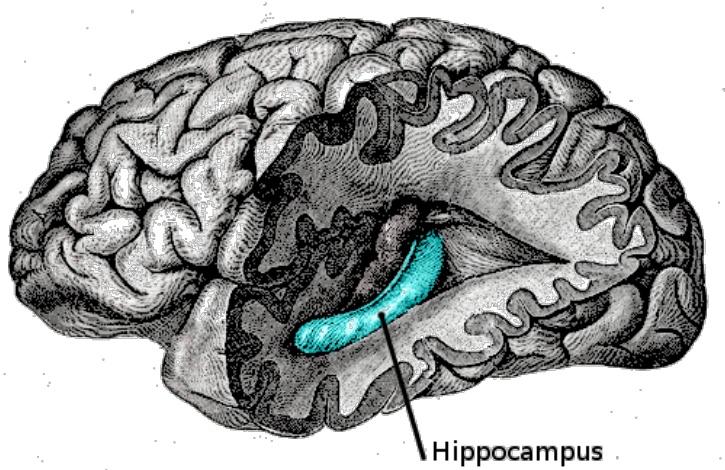


Erickson et al., PNAS, 2011

Cardiovascular fitness may prevent loss of tissue or restore it

Neuroscientists are very excited by **neurogenesis** – the creation of new neurons *throughout life* in an area called the dentate gyrus of the hippocampus.

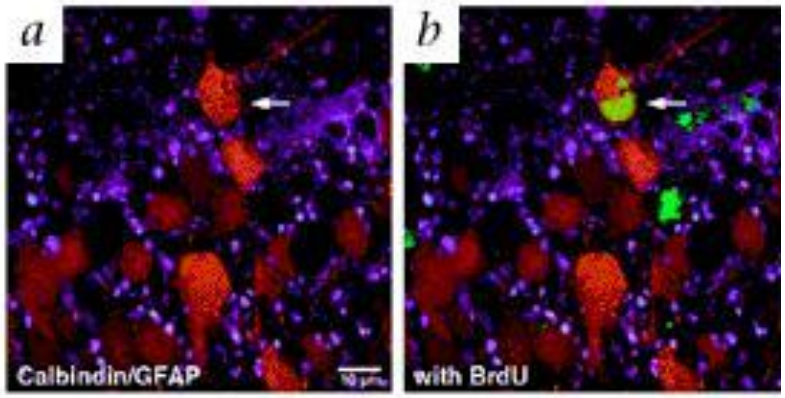
Involved in learning and memory



This finding in humans overturned the century old dogma that no new cells were created in the brain after birth. We now know that this was wrong.

Measuring neurogenesis in humans

Little known about neurogenesis in humans
Difficult to carry out the appropriate experiments

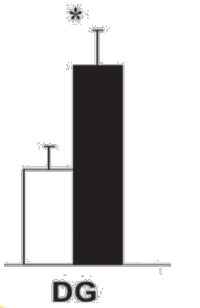


One breakthrough study used a drug to detect brain cancer.
This drug marks proliferating cells and had the fortuitous side effect of identifying newly formed neurons (green blobs) in the adult human.

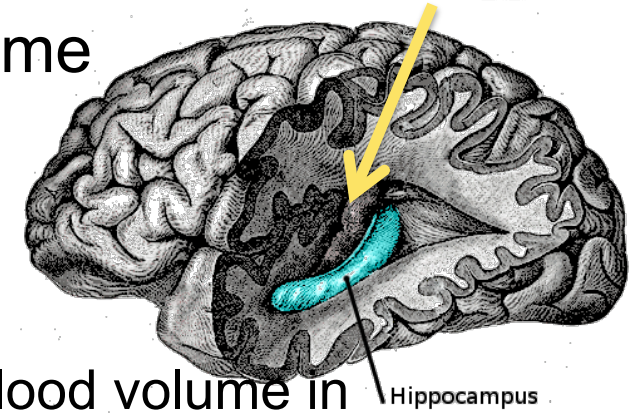
Eriksson et al., 1998

Exercise and neurogenesis

– Rats show effects but human studies rare



– Recent evidence from humans:
  - 3 month aerobic exercise programme
  - Found that exercise increased:
    – cardiac fitness
    – cognitive performance
    – measurements of regional cerebral blood volume in dentate nucleus which relate to increased neurogenesis.



Pereira et al, 2007

Summary

Exercise and neural flexibility

Cognitive training

- Issues in cognitive training:
  - Does practice improve performance?
  - *Does training on one task transfer to other cognitive functions?*
  - Do improvements last?
  - Is it feasible?
  - Jury is out

Practice

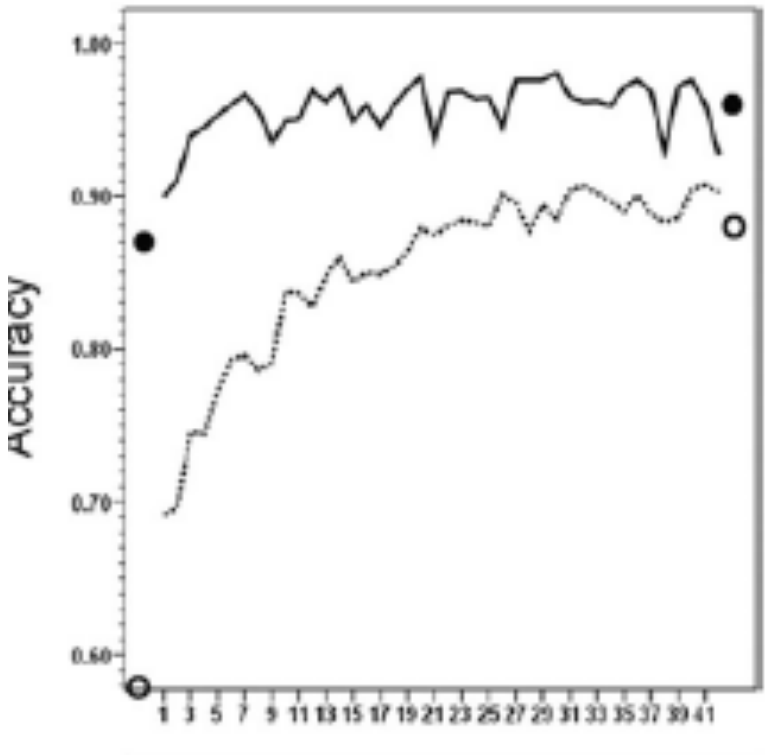
- Practice helps to improve performance at all ages
- It also helps cognitive tasks which tend to decline with age

- *Working memory:*
  - Essential to most everyday activities
  - Declines with age

Practice improves working memory in younger and older adults

Spatial n-back task

Practice: 45 days for 15mins/day



Younger adults

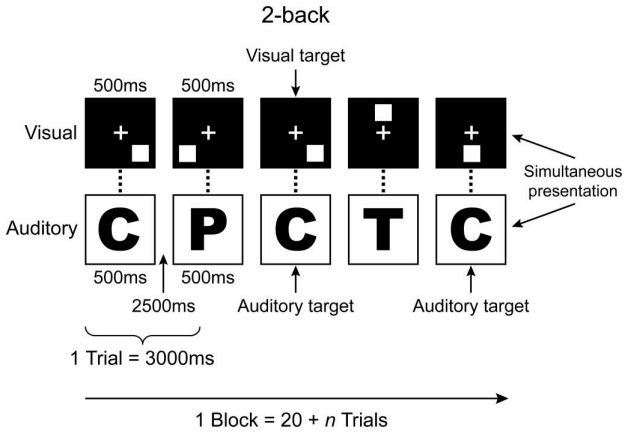
Older adults

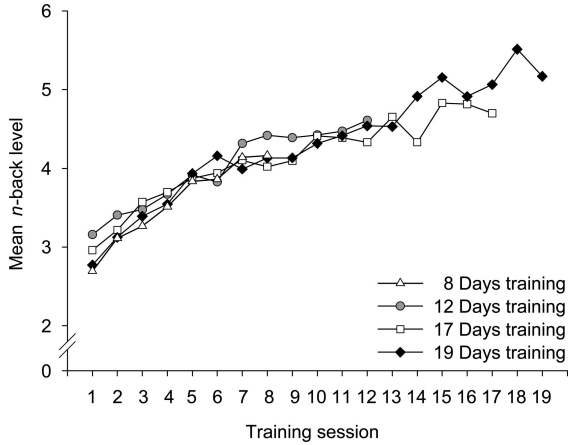
Practice effects maintained for 3 months

Li et al, 2008

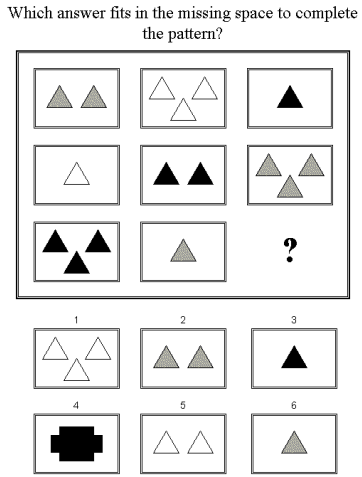
Cognitive training: successful transfer

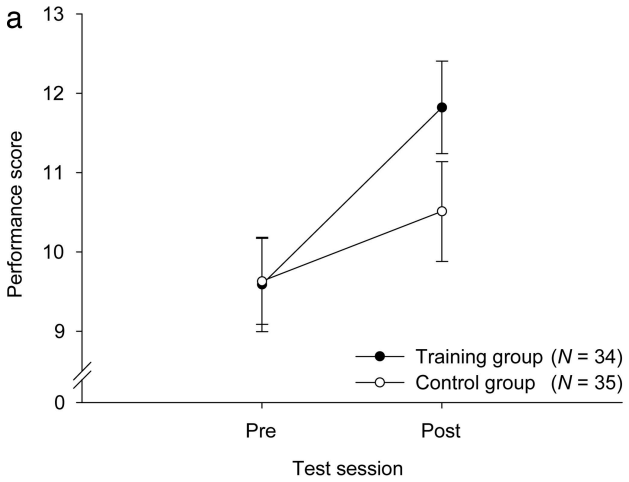
Training: Working memory



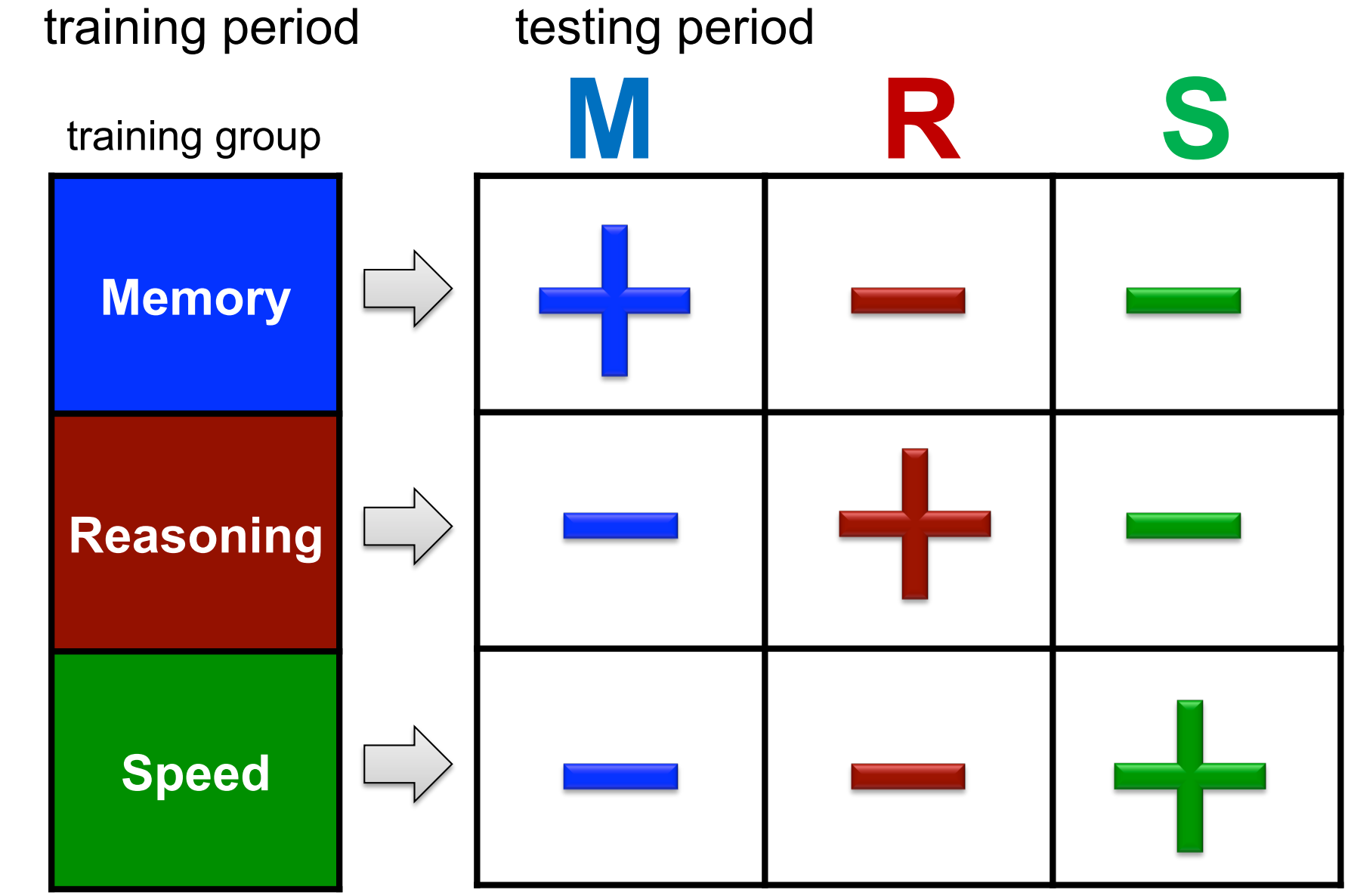


Testing: Fluid intelligence





Jaeggi et al, 2008



2126 subjects

no “transfer” effects

Ball et al., *JAMA*, 2002

Brain training tested on 11,430 people

A Bang Goes the Theory special to help you improve your brain. The science team gives the results of the world's biggest ever brain training experiment and reveals how you can make yourself smarter.

Brain training computer games are big news in Britain and the craze is growing. But does it actually work? The BBC teamed up with leading scientists to devise a huge online experiment to find out. This is genuine, groundbreaking science. And the results are surprising.

- Web-based study
- Trained on variety of cognitive tasks
- 6 weeks

- Improvement on all trained tasks
- No transfer to untrained tasks

Owen et al, 2010

Summary

- Clear evidence that practice improves performance
- Jury is out on whether practice transfers to new tasks/cognitive domains
  - Depends on relationship between training and testing tasks etc

Summary

- Brain health is the key
- Brain is more resilient than we once thought.

  It can adapt to age-related neural changes
  - By means of functional reorganisation
  - By means of some externally-induced changes

  In so doing cognition can be maintained

  What does this mean for us?

Importance of negative stereotypes of aging: Can have consequences for cognition and physical health

- Many older adults think they're failing.
- Up to half of people over 65 say they have subjective memory problems.
- and the more you accept this view, the more you seem to succumb to it….

Effect of negative stereotypes

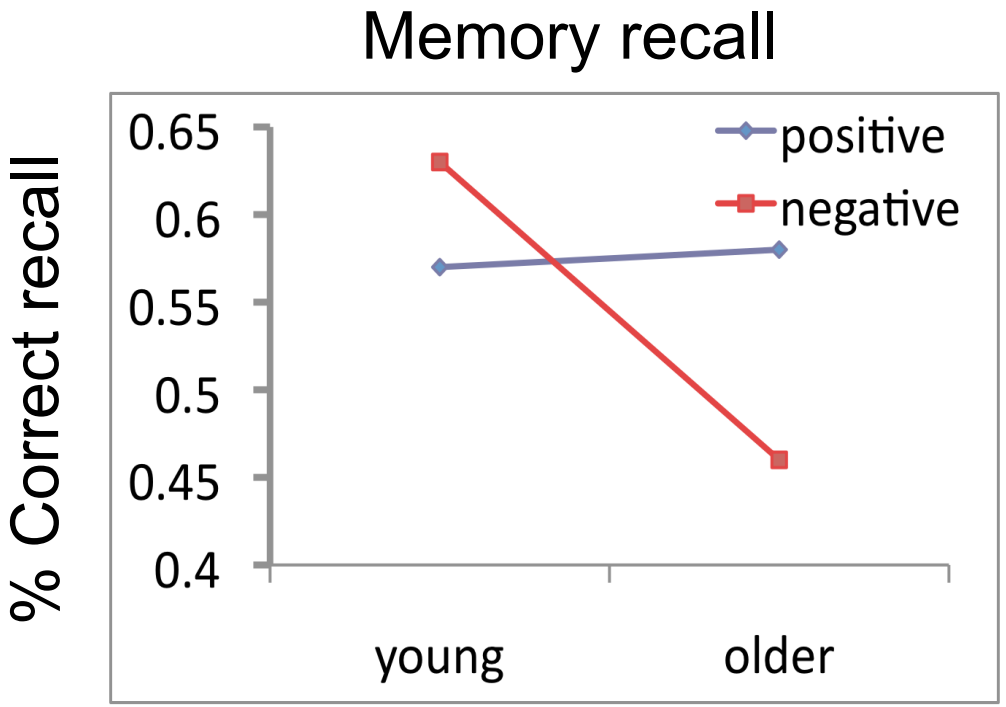
1. Generate a sentence

Positive set: high, are, wise, prices, gas

Negative set: ran, cranky, dog, the, home

2. Memorize list of words

Goat, tree, stapler, engine, bicycle etc ....

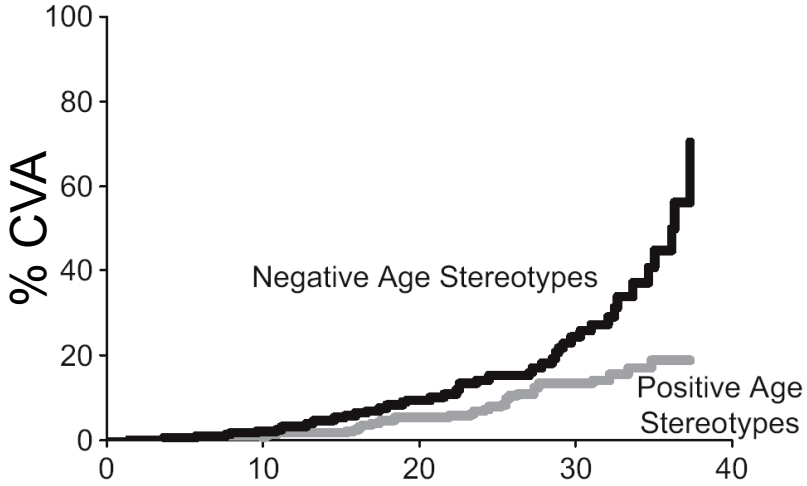


Older adults conform to negative stereotypes of aging which affects their cognitive performance

Hess et al, 2004

Effect of negative stereotypes

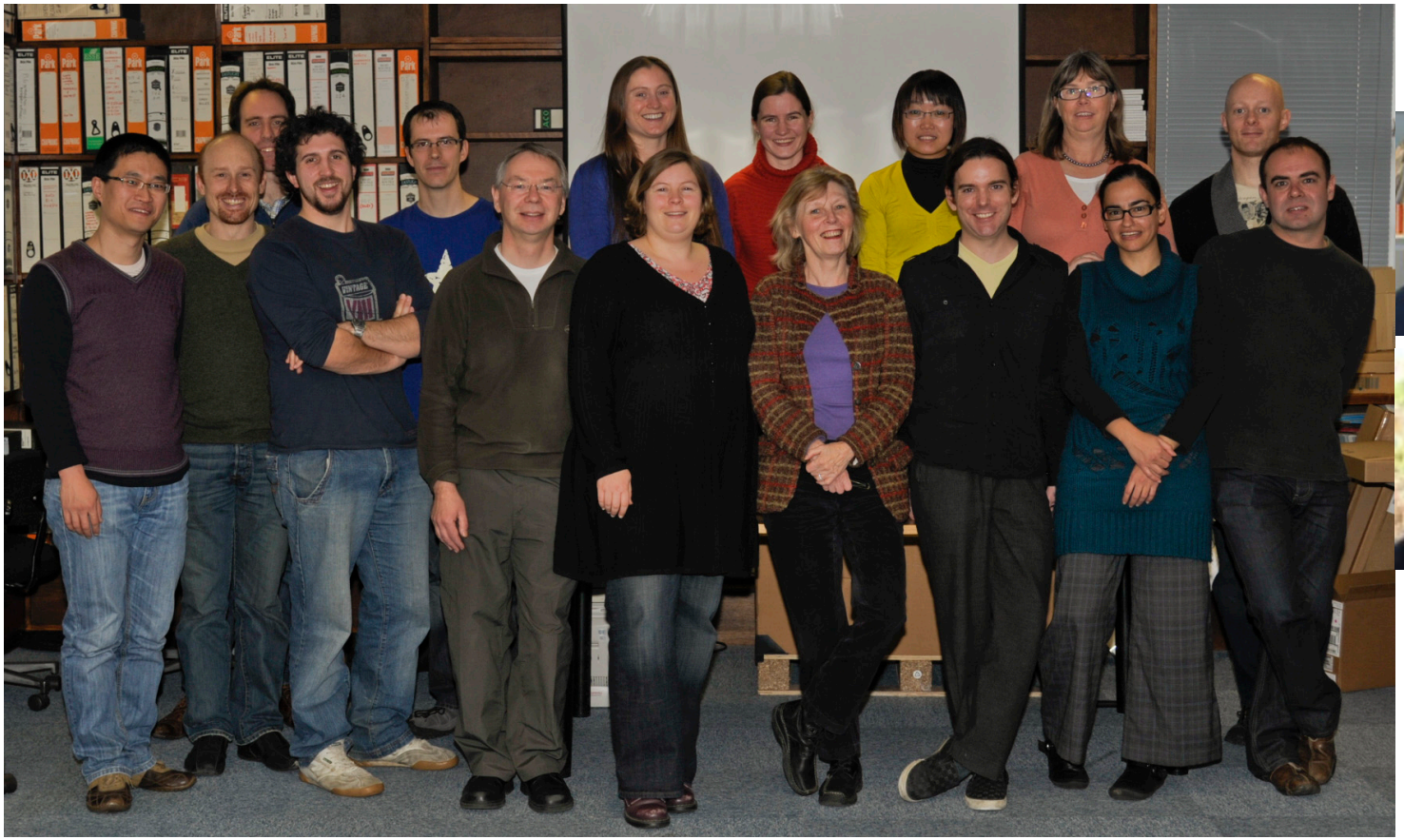
- People aged 18-48 evaluated for their attitudes towards older people
- Their first cardiovascular event recorded
- Other health and lifestyle factors controlled for

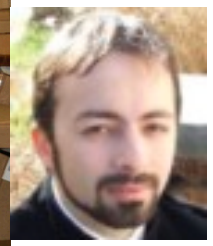


Increasing numbers of people with negative aging stereotypes have CV event over time

Levy et al, 2009

Thanks to





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