



# Neuroscience and Education: Why we need authentic collaboration

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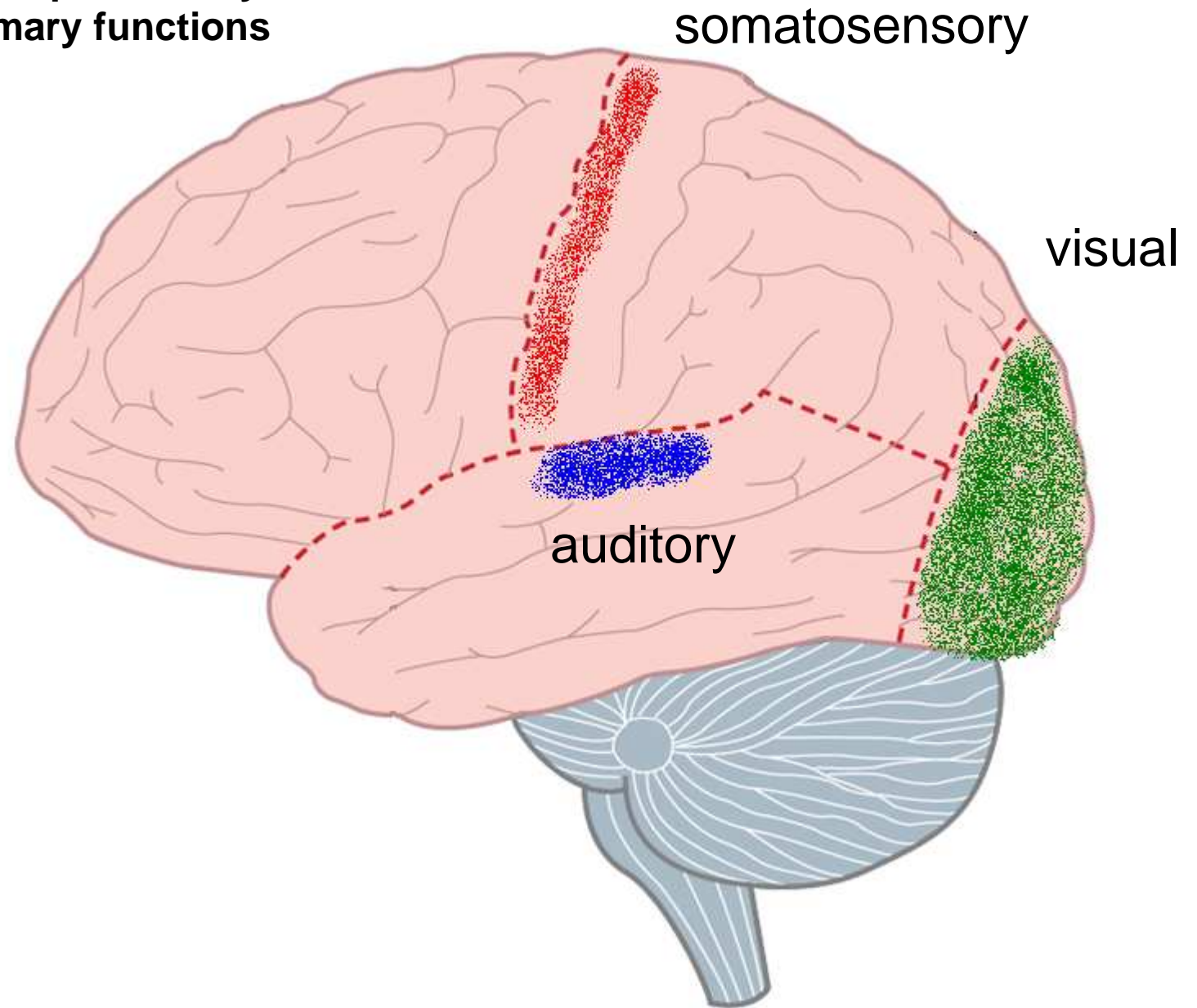
# Neuroscience and Education: 1. Neuromyth

Most (almost 90 per cent) of teachers think that a knowledge of the brain is important, or very important, in the design of educational programmes

Howard-Jones et al. 2007

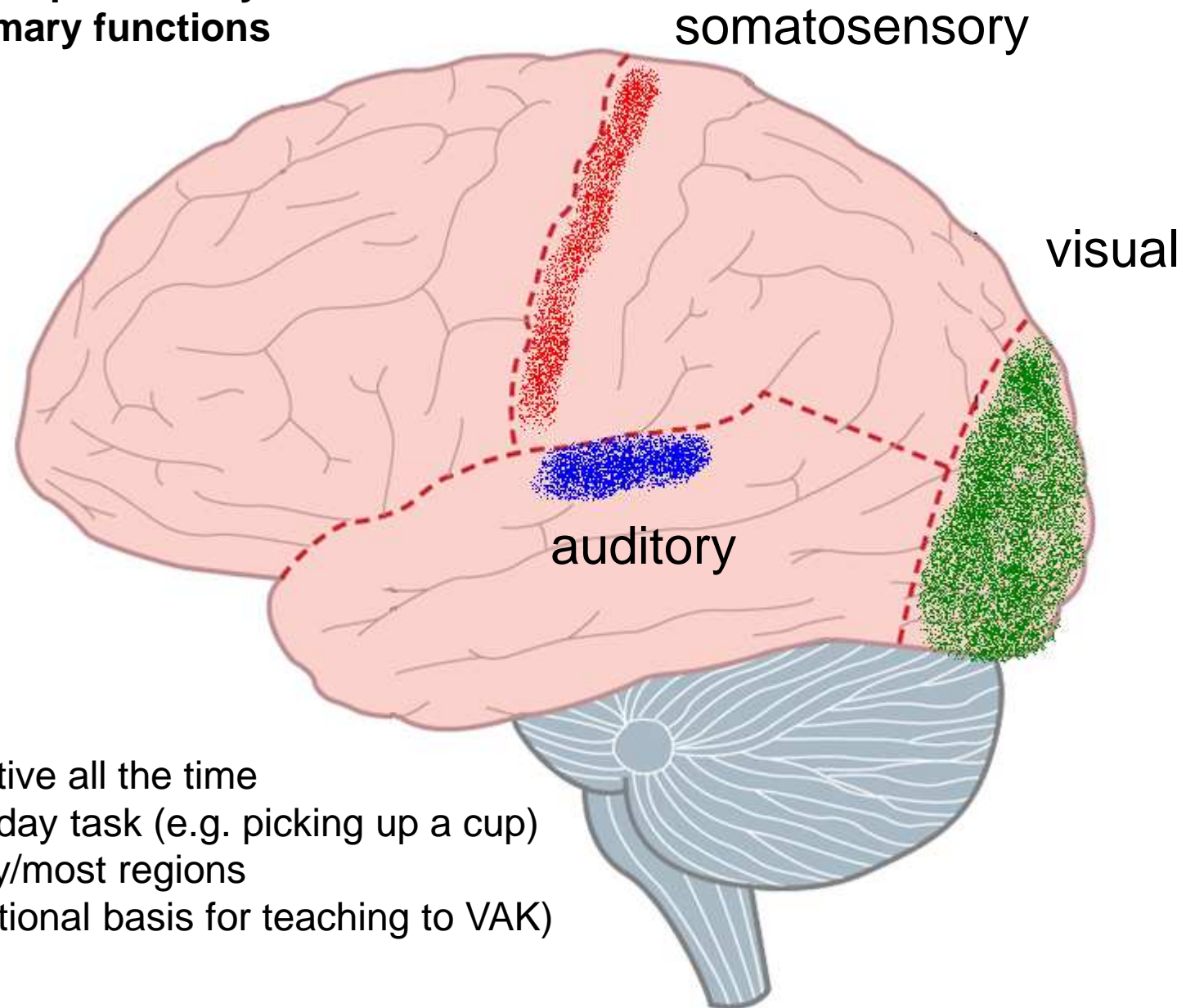
<b>Myth (% teachers of believe)</b>	<b>UK</b>	<b>NetherInd</b>	<b>Turkey</b>	<b>Greece</b>	<b>China</b>
<b>We only use 10% of our brain</b>	48	46	50	45	59
<b>Individuals learn better using preferred learning style(e.g. VAK)</b>	93	96	97	97	97
<b>Co-ordination exercises improve left/right brain integration</b>	88	82	72	56	84
<b>Hemispheric dominance (left/right) helps explain individual differences</b>	91	86	79	71	71
<b>Children are less attentive after sugary drinks and snacks</b>	57	55	44	48	62
<b>Drinking less than 6-8 glasses of water shrinks the brain</b>	29	16	25	12	5
<b>Learning problems linked to brain differences cannot be remediated by education</b>	16	19	22	29	50

**Some regions are particularly associated with certain primary functions**



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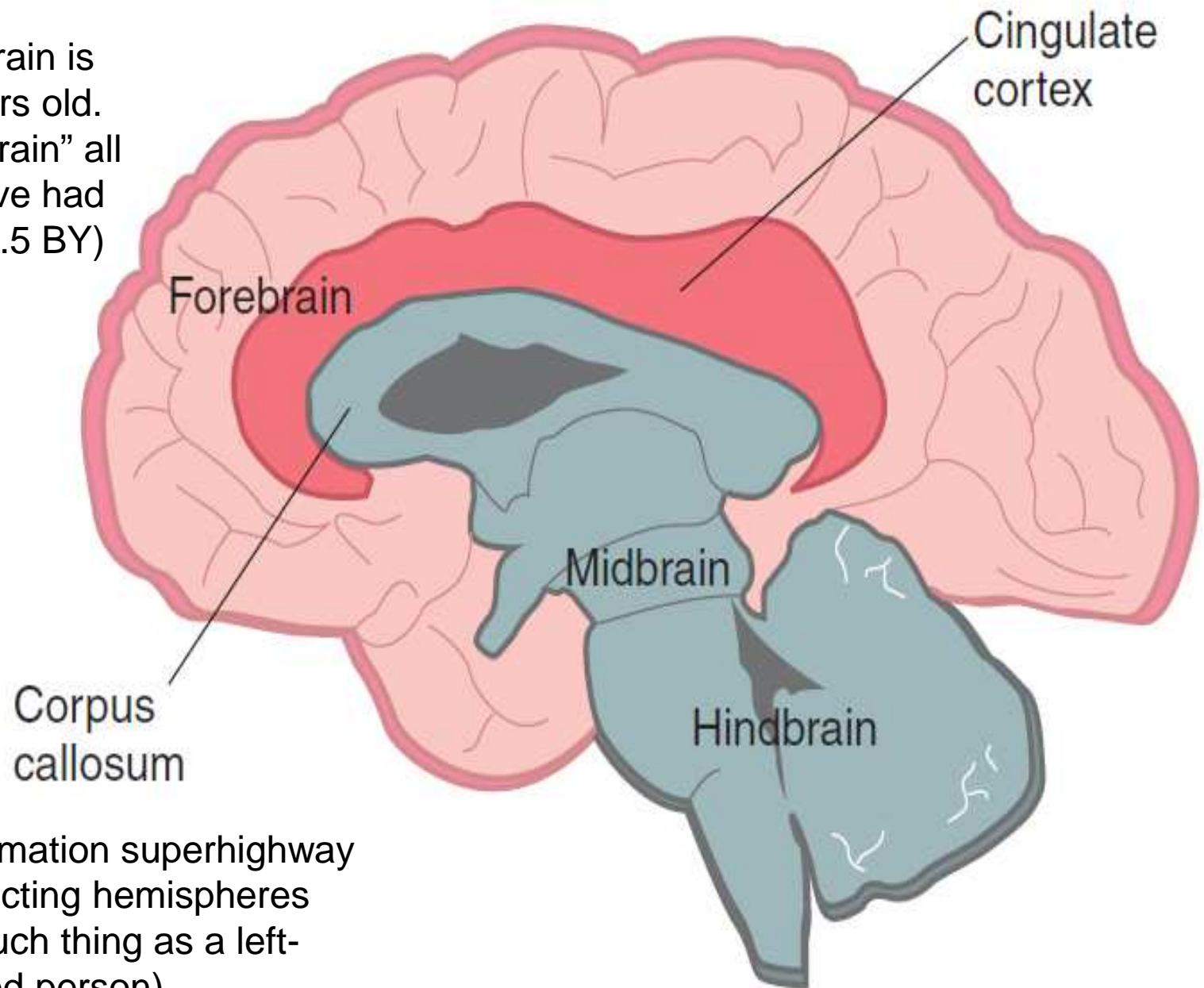
**But....**the brain is massively interconnected (e.g. seeing a bell activates auditory cortex)



All the brain is active all the time  
Any simple everyday task (e.g. picking up a cup)  
may involve many/most regions  
(No neural/educational basis for teaching to VAK)

## Cross-sectional (sagittal) view:

The tripartite brain is 0.5 billions years old. (No “reptilian brain” all vertebrates have had all 3 parts for 0.5 BY)



=Information superhighway connecting hemispheres (No such thing as a left-brained person)

# So what's good and bad for brains?



Auditory



Visual





- News Front Page
  - World
  - UK
  - England
  - N Ireland
  - Scotland
  - Wales
  - Politics
  - Business
  - Entertainment
  - Science/Nature
  - Technology
  - Health
  - Education**
  - Hot Topics
  - UK Systems
  - League Tables
  - Features
- 
- Talking Point
- 
- Country Profiles
  - In Depth
- 
- Programmes

## Water coolers to help pupils think



Children's attention spans are short. A campaign has been launched in schools to encourage children to drink more water to increase their concentration. Studies have found that children who are dehydrated do not perform as well in the classroom as those who are hydrated.

## Water improves school test results



Water refreshes the parts of the brain that others can't reach. An experiment in Scotland claims that pupils' test results improve if they drink more water. Pupils at Corstorphine School in Edinburgh have been drinking water throughout the primary school day - and have seen test results improving to the extent that they have already exceeded targets set for 2002. The theory under consideration is that the human brain uses water in its transmission of neural messages - and that if children are regularly hydrated their brains are better physically equipped to learn.

“Let’s drink water, I love water. It gives me En-er-gy”

## Water aids thirst for knowledge

low graphics



Water bottles in the classrooms in Merseyside are to receive free water after teachers found that children's concentration levels were low.

# DRINK MORE WATER!?

# Water: What's the evidence?

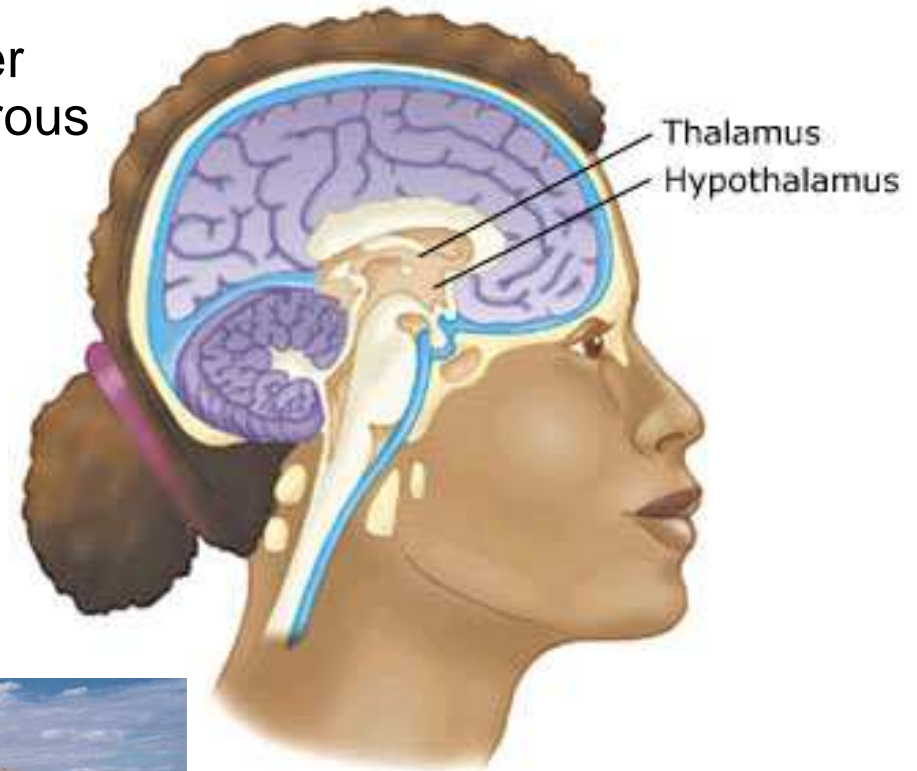
- 80% of your brain IS water
- Even mild dehydration CAN decrease you ability to think
- Drinking too little water CAN result in serious illness and even death.
- People DO feel more attentive after a drink of water
- There is a popular idea that we need 6-8 glasses of water a day (most teachers aren't sure, but think the brain may otherwise shrink, 1 in 5 sure it will)

# However.....

- “Feeling” more attentive is NOT the same as being more attentive.....
- Drinking water when not thirsty can ALSO reduce your ability to think
- Drinking too much water can ALSO result in serious illness and even death

# How do we (usually) know when we need water?

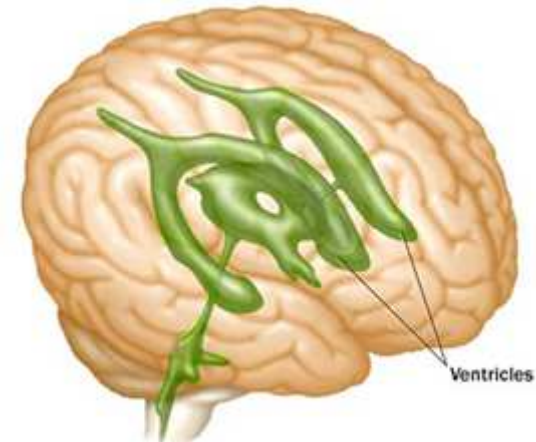
- The “hypothalamus” relays signals about body state – so that we feel **thirsty** when our bodies (and brains) need water
- So normally no need to monitor water (except in unusual heat or after vigorous exercise)
- Voluntary dehydration amongst normal population is rare **except** for heat and/or exercise – e.g. dehydrated school children in a classroom next to the Dead Sea – the lowest & one of the hottest places (up to 40 degrees) in the world.



# Water

- Can your brain shrink with less than 6-8 glasses of water a day? **NO** and experts have concluded 6-8 glasses are too much in normal conditions. One study shows dehydration due to exercise can result in slight enlargement of ventricles:

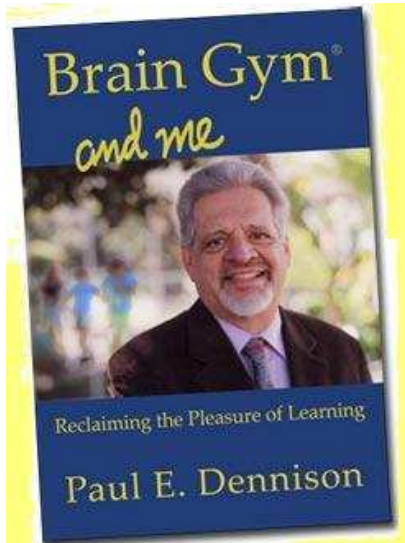
But no cognitive effect associated with this....



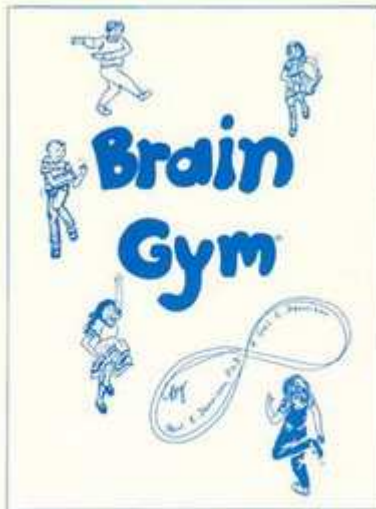
- There is one example of brain shrinkage due to dehydration – a man in Japan reported by scientists in 20







**SCIENTIFICLY  
PROVEN**



**Teacher's Edition  
Revised**

# Brain Gym



E.g. In Brain Gym, “brain buttons” are indentations between the 1st and 2nd ribs directly under the collar bone to the right and left of the breastbone.

If you provide pressure at these points, they can help re-establish correct brain organisation required for thinking and learning?!

# Omega 3 – fish oils



BBC HOMEPAGE | WORLD SERVICE | EDUCATION

BBC NEWS

Science & Nature: Human Body & Mind

## Omega 3 – the Durham School Trials



Elliot is nine years old. A year ago, he was falling behind in his schoolwork, particularly reading – which he found a struggle. He had little interest in studying and would crash on the sofa to watch TV when he got home from school.

But over the past year, a dramatic change has taken place in Elliot. He has soared through the Harry Potter books and now heads to the library after the school bell has sounded.



# Omega 3 – fish & fish oils

- Mixed results from supplements to children with ADHD
- Children with poor cognitive development have less Omega 3
- 2 studies for general population in mainstream education show little, if any, effects.
- Children whose parents give them supplements do better at school....whatever the supplement!

“Keep your brain healthy with new *Kellogg's® Live Bright™* Brain Health Bars”!??



# Learning styles (VAK)

- Visual, Auditory, Kinaesthetic – based on neuroscience (?)



Auditory



Visual

- 82% of teachers believe in teaching to learning styles
- NO evidence for educational benefit (despite MANY studies)
- NO basis in neuroscience
- Scientists: NO benefit of having info in one's preferred learning style, this is "wasted effort"
- More benefit from all students receiving all styles



# Caffeine

- Children and adults commonly experience caffeine withdrawal (headaches, fatigue)
- Children usually drink 2 cans a day of cola a day are LESS alert than low users. Similar results with “users” amongst adults
- Alertness rises to normal when users receive some caffeine and then, of course, only temporarily.

(67% of teachers don't know this)



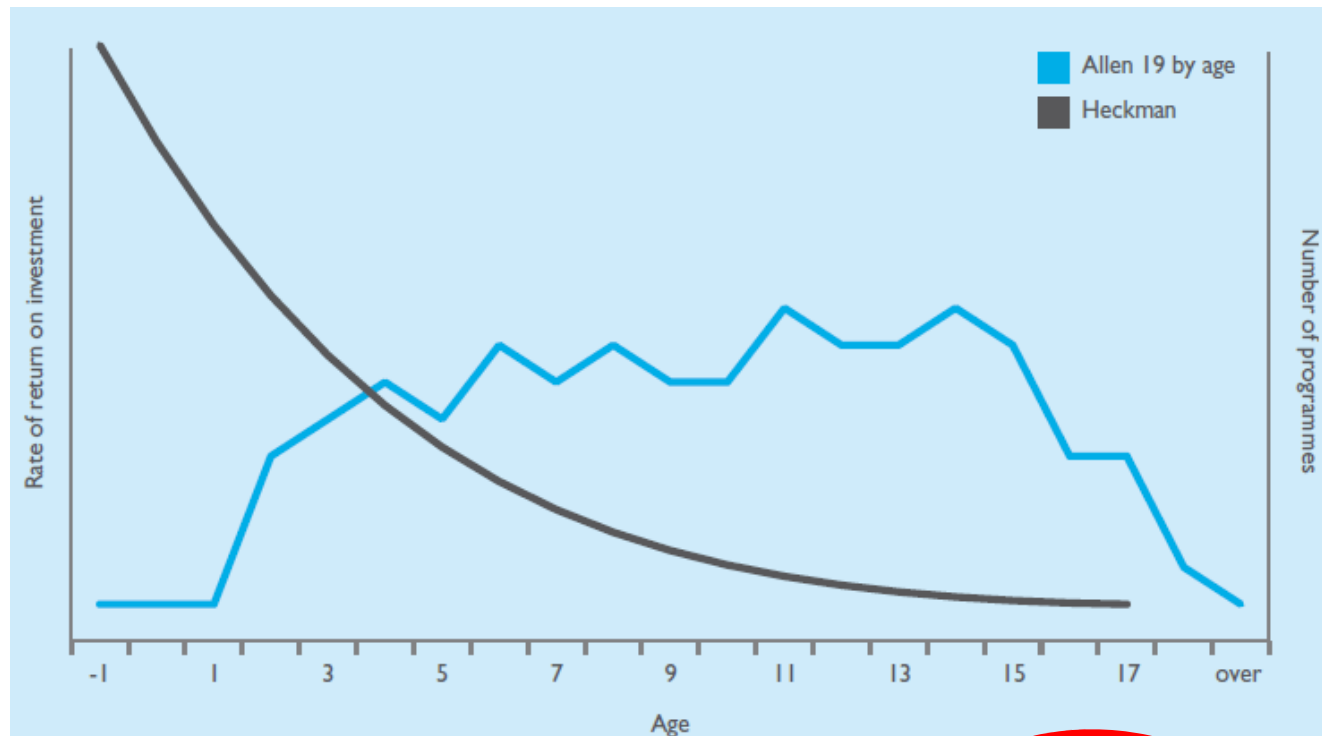
= ~3 cups of coffee



# MAKING SENSE OF EARLY INTERVENTION

THE CENTRE FOR  
SOCIAL  
JUSTICE

A framework for professionals



*“The Heckman curve to which Allen himself refers shows that investment early in life produces better returns.....”*



Demonstrators smashed windows of a building in Millbank in Westminster.

Howard-Jones, P. A., Washbrook, E. V., & Meadows, S. (2012). The timing of educational investment: A neuroscientific perspective. *Developmental Cognitive Neuroscience, 2, Supplement 1(0), S18-S29.*

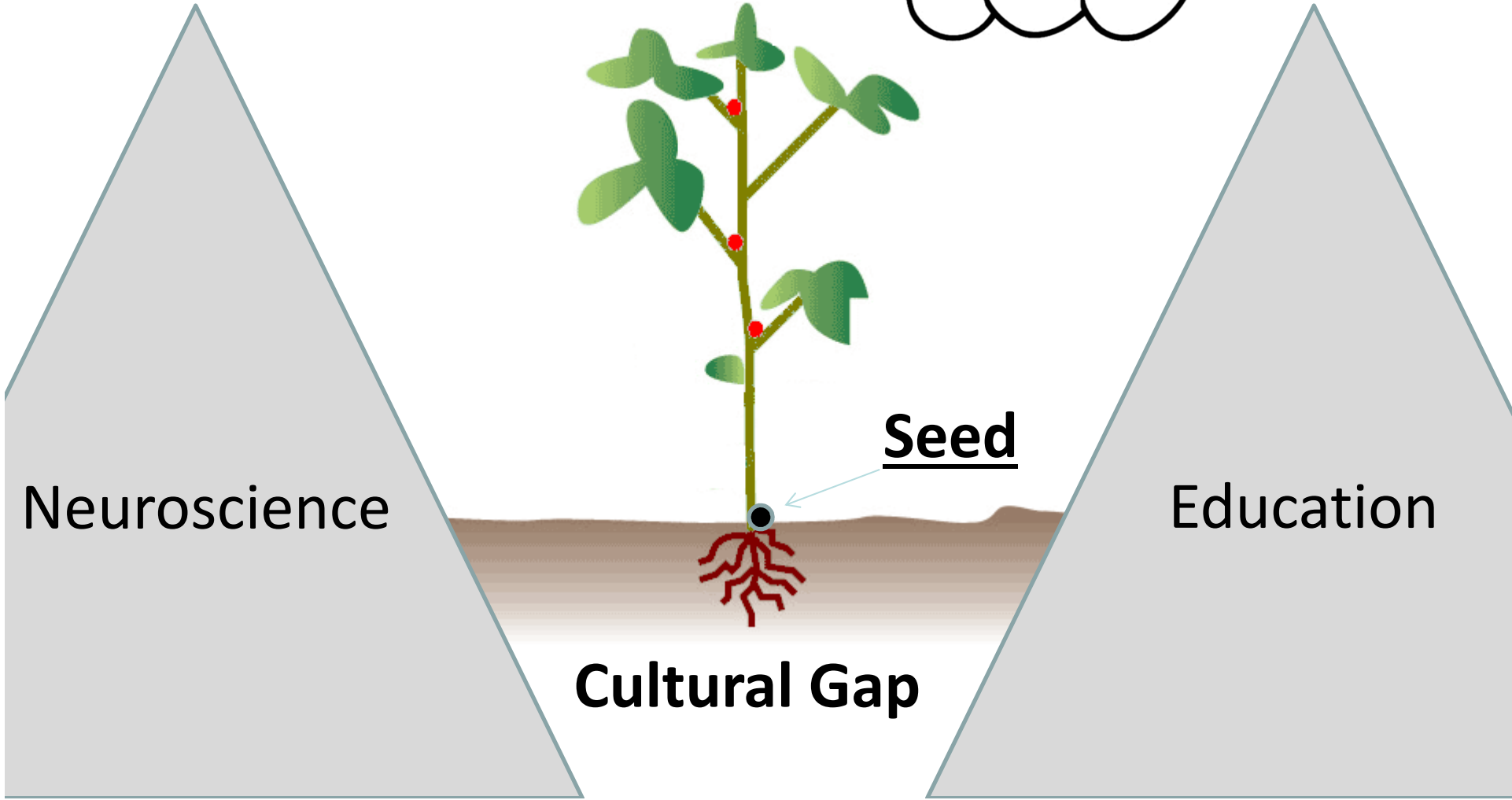
# Seeds of confusion

FACT	MYTH
Learners benefit from receiving information in a variety of modalities (auditory, visual, sensory)	Learners benefit from being taught in their preferred learning style
Language is generally left-lateralised	Learners can be helpfully categorised as left-brained or right-brained
Dehydration can reduce cognitive functioning	Less than 6-8 glasses of water a day causes the brain to shrink
Aerobic exercise is good for the brain, improving mental function and our ability to learn	Exercises that rehearse co-ordination of motor-perception skills can improve literacy skills
The younger brain is more plastic	The trajectory of brain development is effectively fixed by 3 years old

How a neuromyth grows.....



**Bias**



Seed

Neuroscience

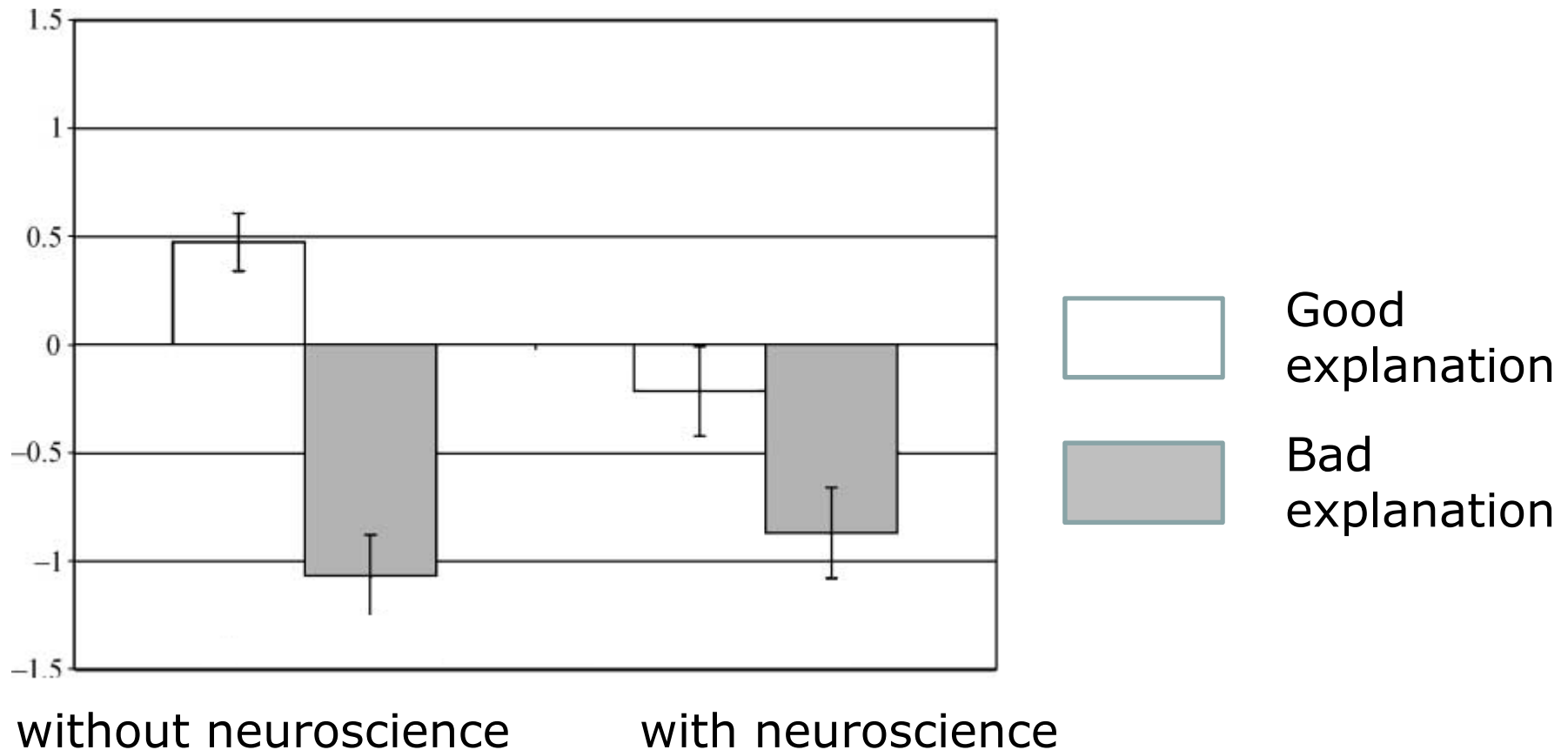
Education

**Cultural Gap**

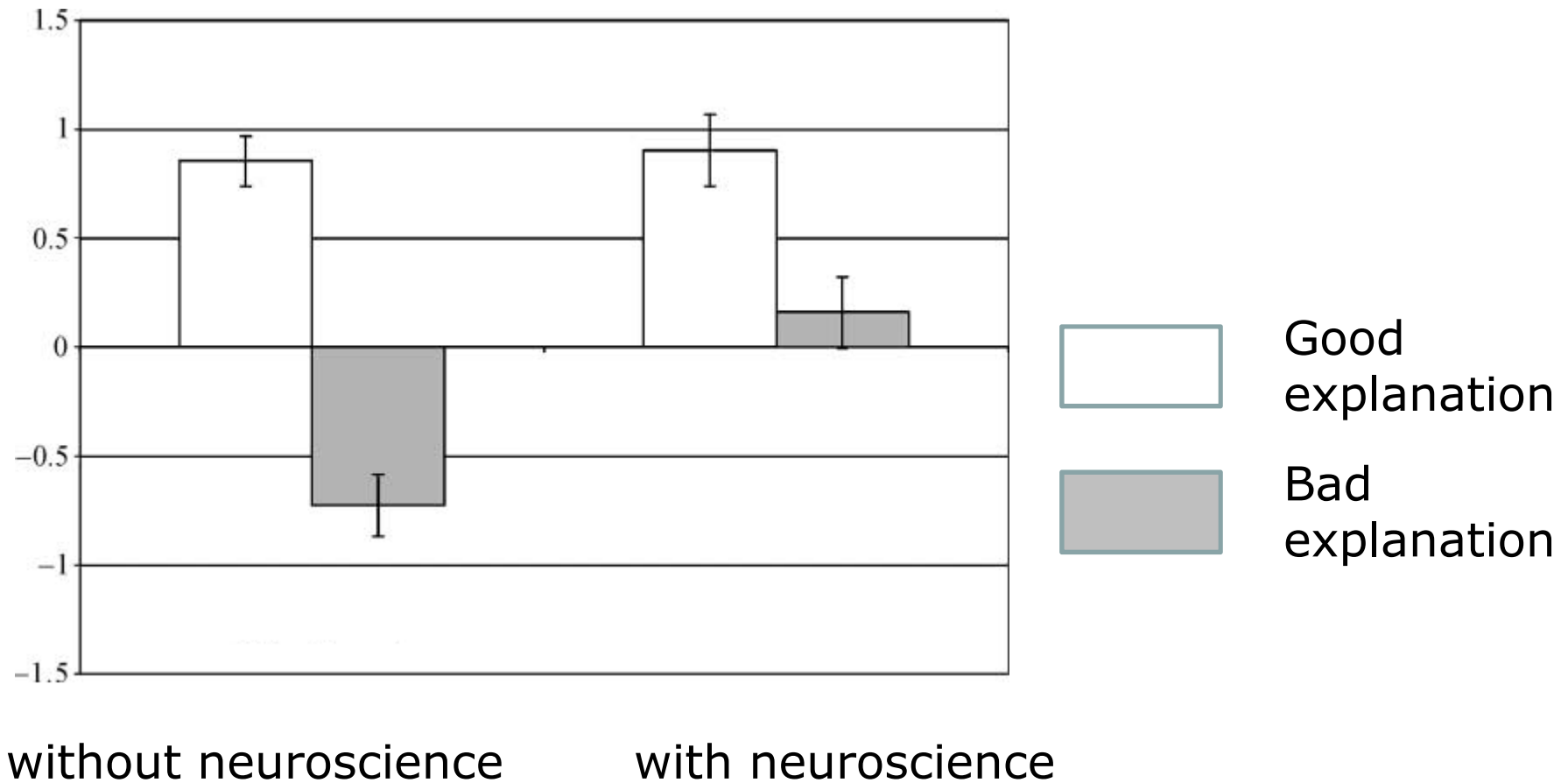


# Neuroscience has “allure”

## Effect of irrelevant NS on Experts



# The effect of irrelevant NS on Public



It's based on  
neuroscience!

~~Wow - must be  
true!~~

Who says so....are  
they neuroscientist?

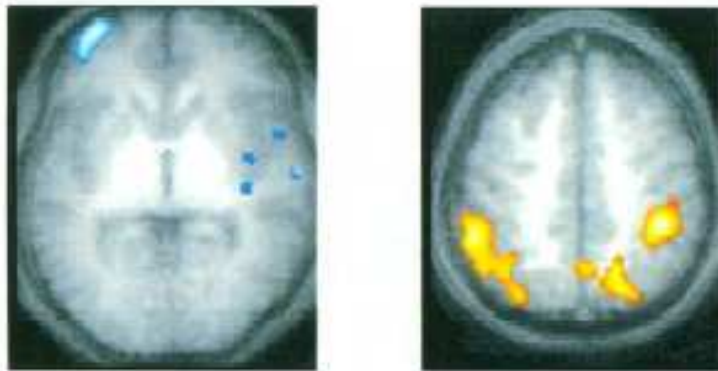
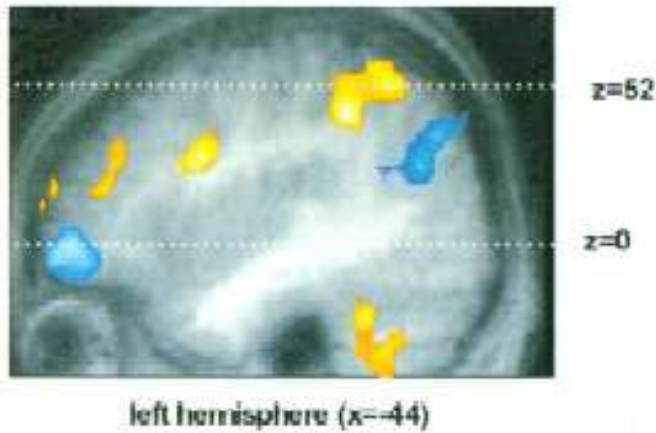
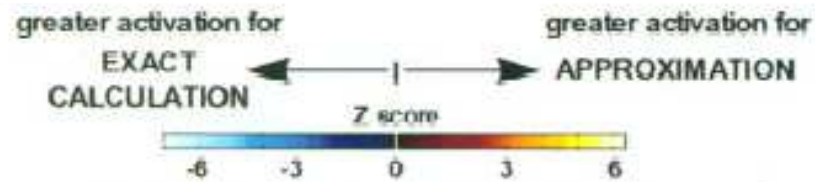
Where was it published?

# Neuroscience and Education:

## 2. Authentic Application

# Mathematics

## New and Old



Dehaene et al. (1999)

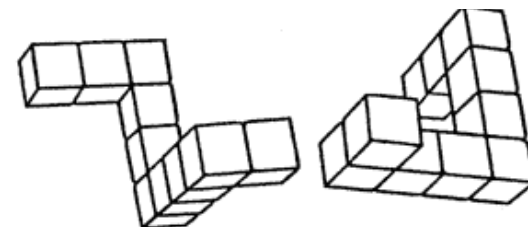
## Fingers



## Anxiety



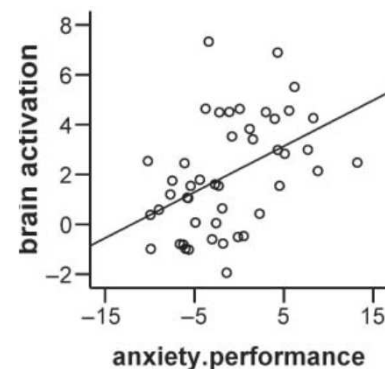
## Mental Rotation



# Stress and anxiety

Mild stress can improve learning when occurring in same space and time in external and internal environment (i.e. brain) (Joels et al. 2006)

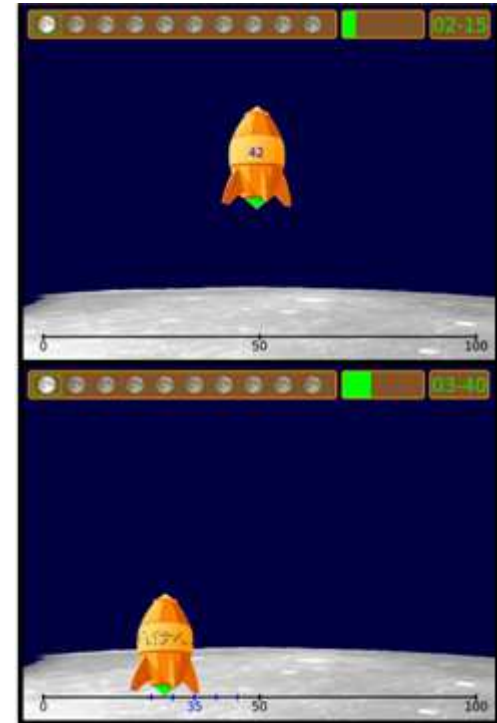
Otherwise....anxiety can decrease working memory (WM) efficiency, as demonstrated in greater functional connectivity required for WM tasks amongst trait anxious individuals (Basten et al., 2011) A study has reported that the effects of teenage maths anxiety can be reduced by writing about it (Ramirez et al. 2012)



# Mathematics

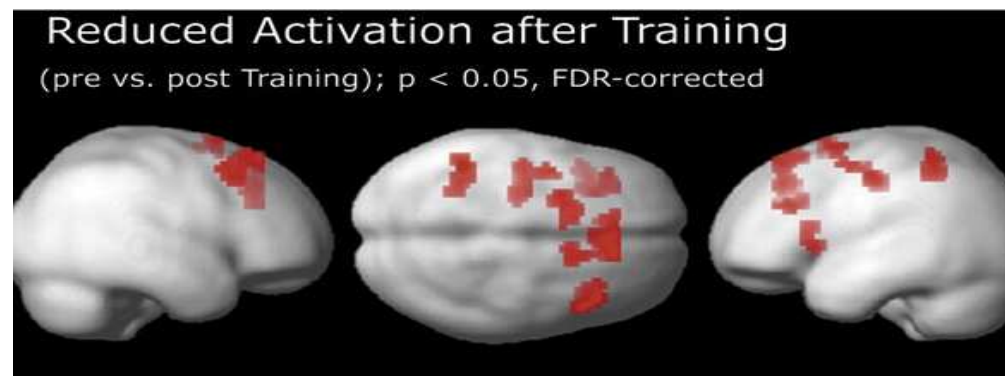
“Rescue Calcularis” (Kucian et al. 2012)

Neuroscience by design, for evaluation

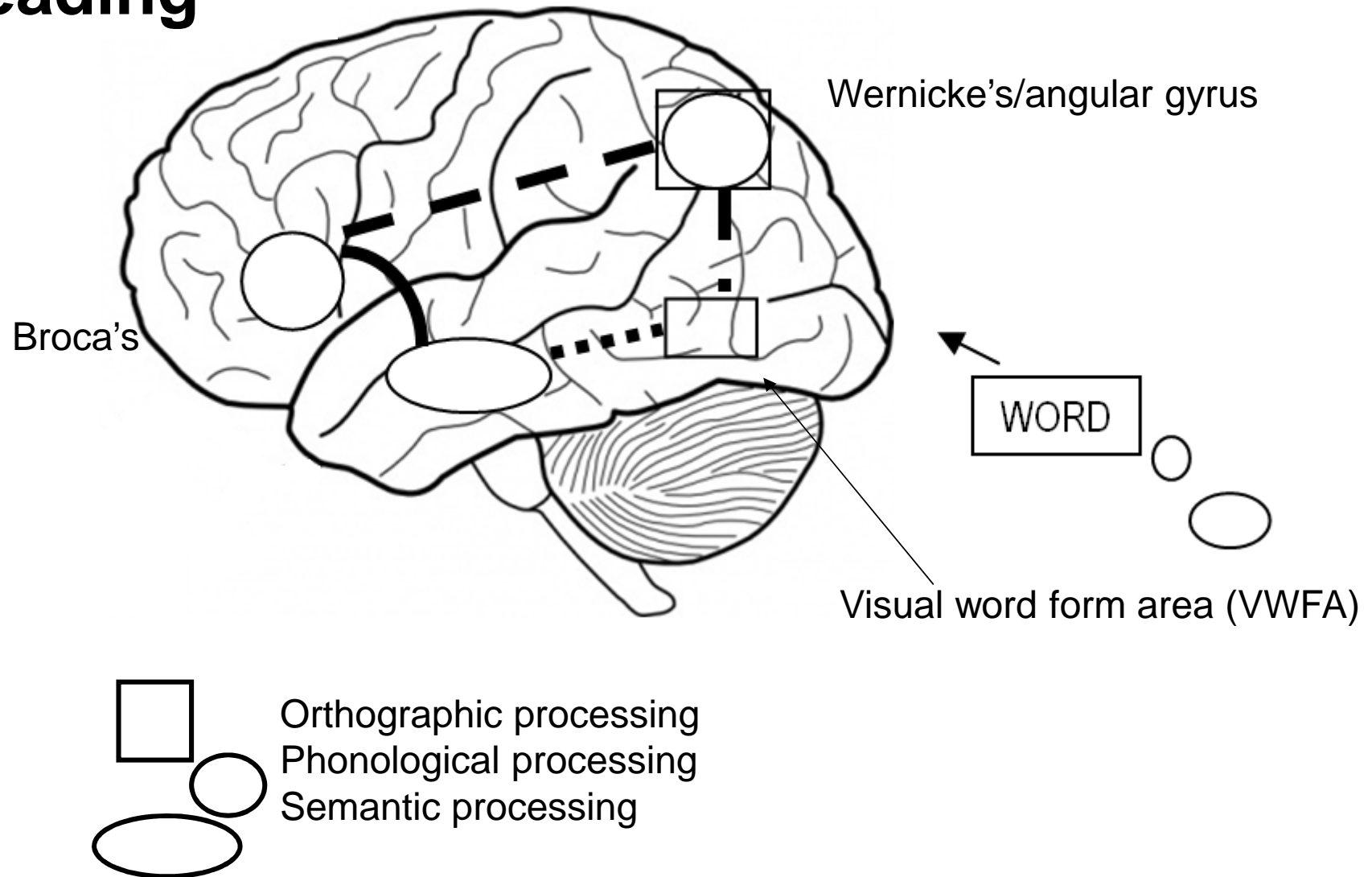


Improved number line and maths for dyscalculics and controls.

Reduced frontoparietal activity:



# Reading

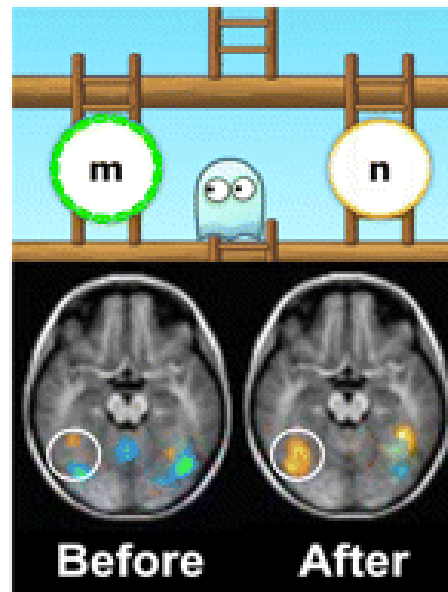
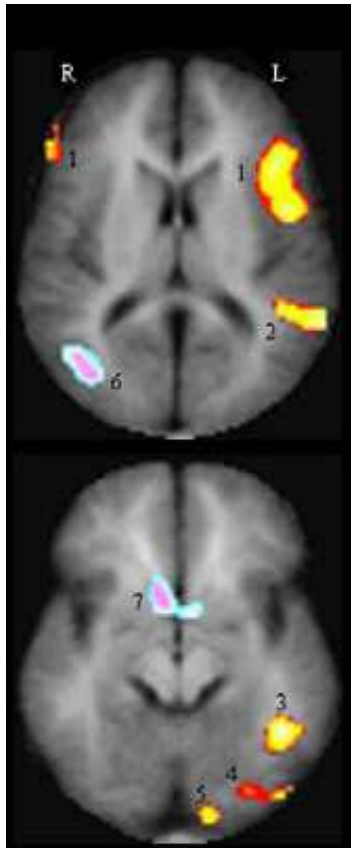


So reading systems are distributed, and contain redundancy

Ashby(2012)

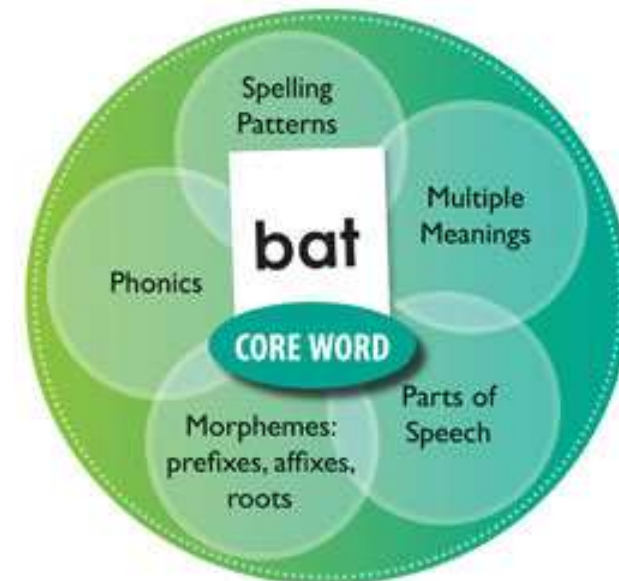


**Phonological interventions** remediate reading, activation (3=VWFA)  
(Shaywitz et al., 2004)



### Early literacy – non-readers

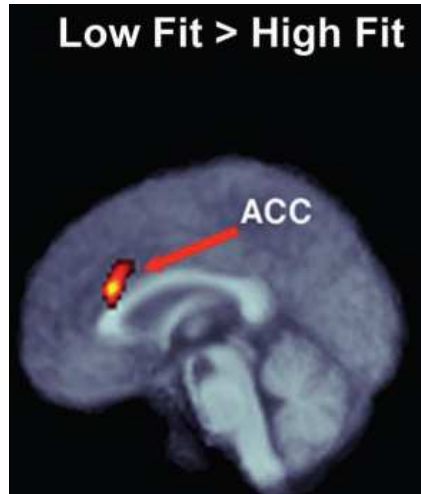
Graphogame improves outcomes  
increases VWFA activity Brem al.(2010)



But...a multicomponent process amenable to multicomponent interventions....

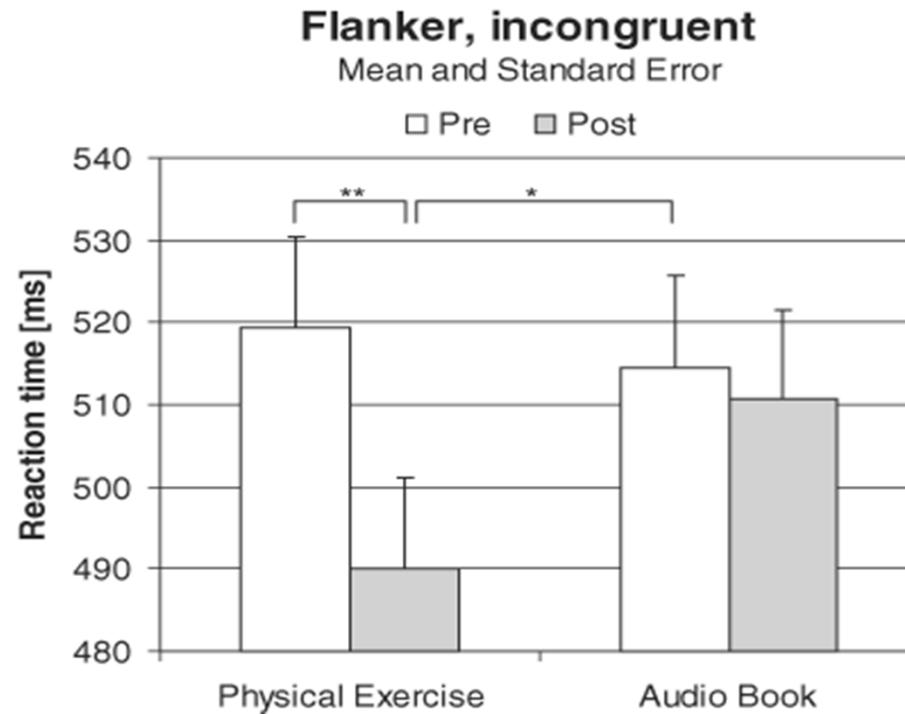
- Computer-based training focused on phonological skills has helped those experiencing difficulty to develop their reading skills.
- Several multicomponent interventions also successful. Potential value in considering individual differences in such interventions

# Exercise



Exercise enhances executive control functions + structures

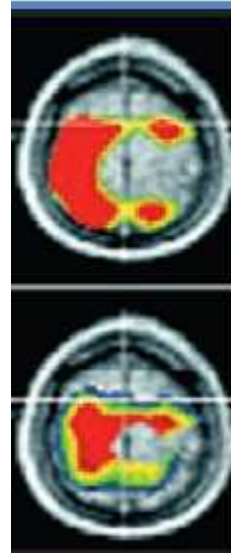
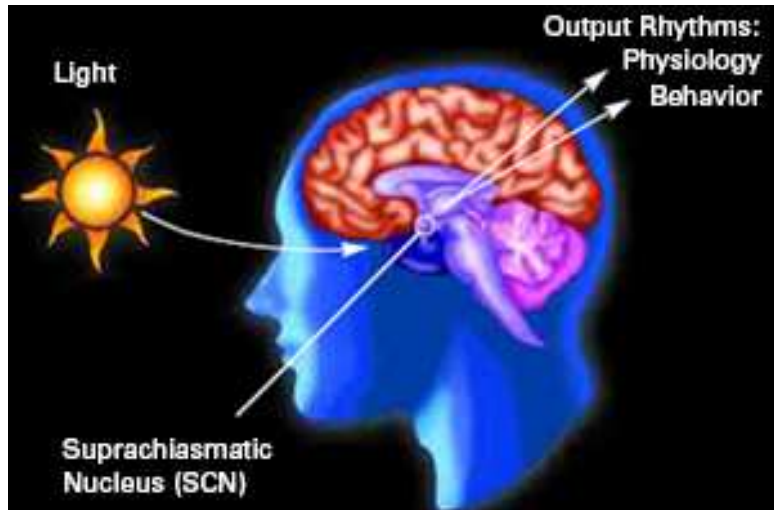
E.g. anterior cingulate cortex (ACC)  
Colcombe et al. (2004)



Single 30-min PE versus rest  
13- to 14-year-old students  
Kubesch et al. (2009)

- \* Many exercise interventions suggesting academic value – but need to consider content of intervention.
- \* Well-established benefits of physical fitness and exercise on brain health and cognitive function, including even almost *immediate effects*, e.g. two 3 minute sprints improve subsequent memory in short, medium & long term

# Teenage Lifestyle

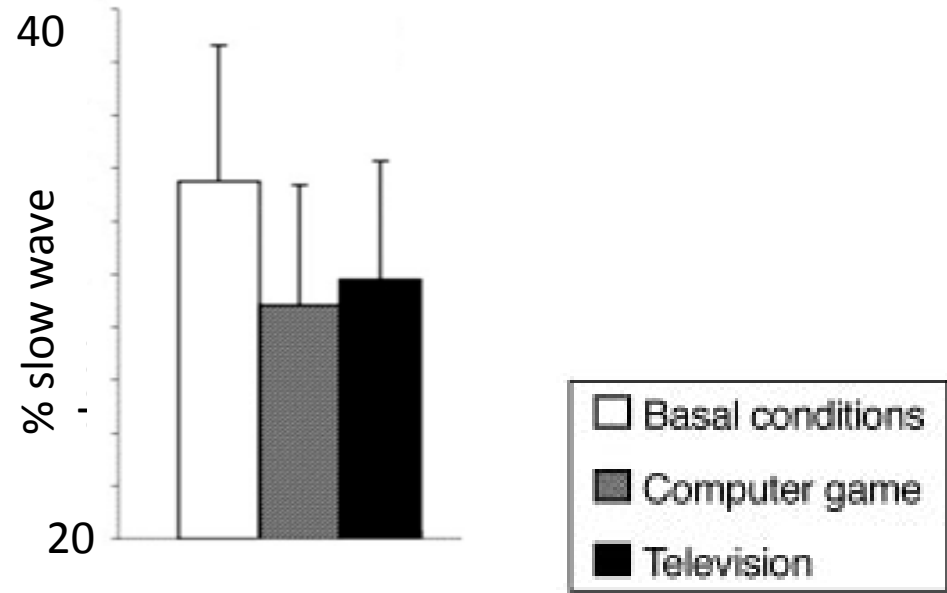


Red Bull gives you angel wings

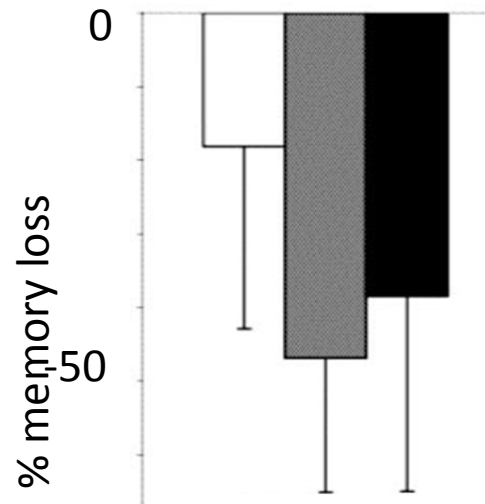
# Many issues re: **Technology-brain-learning**

13-14 yr olds (N=11), 6-7pm

- \* playing computer games
- \* watching TV or
- \* neither (basal condition)



Later in evening asked to memorise 2 mins of facts.



Dworak et al. (2007)

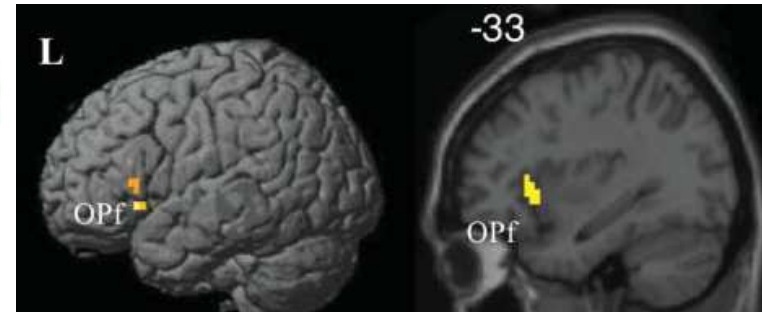
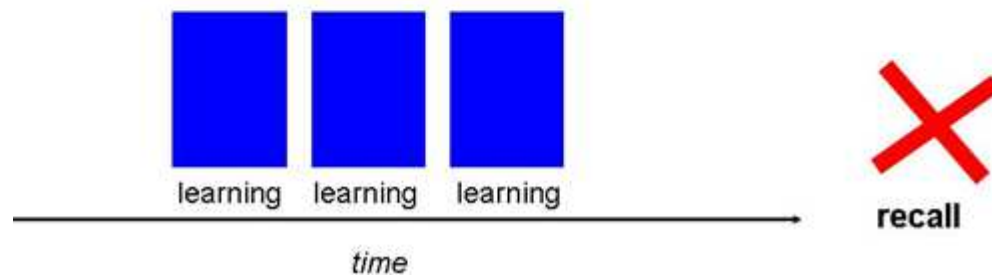
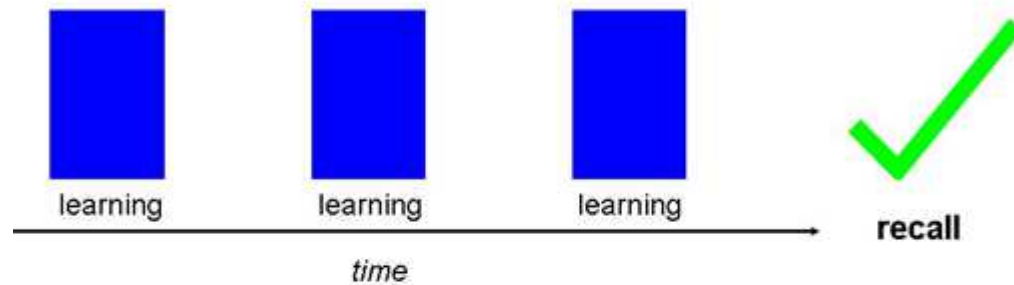
## ***Teenage Lifestyle***

*Would teenagers achieve more if they were allowed to sleep later?*

Also....involvement of sleep education interventions with homelife and culture has shown, tentatively, more promise



# Spacing and Interleaving effects



Greater left frontal operculum (auditory-to-articulatory) mapping – suggests greater need to re-encode in spaced sessions (Callan et al, 2010)

- The spacing effect on memorisation is well-established, and the benefits of spacing may extend to deeper types of learning
- Interleaving more complex and less established than spacing effect, but small number of studies reveal potential

# And also.....

- Attention-deficit hyperactivity (ADHD) and other disorders
  - How learners visualize & imitate
  - Working memory training
  - Adolescence (EF, risk, brain awareness)
  - Timing of educational investment....
- ...and much more...

# Reward and Educational Learning

- Engagement strongly predicts school outcome
- Engagement declines in early adolescence, especially STEM, especially disadvantaged
- Rewards already used to engage, but w/o theory. The amount of reward does not seem related to achievement



jobs dating more - UK edition -

**theguardian**  
Winner of the Pulitzer prize

UK world sport football opinion culture economy lifestyle fashion env

home > education students teacher network

GCSEs

## Student rewards such as cash and free trips fail to improve GCSE results

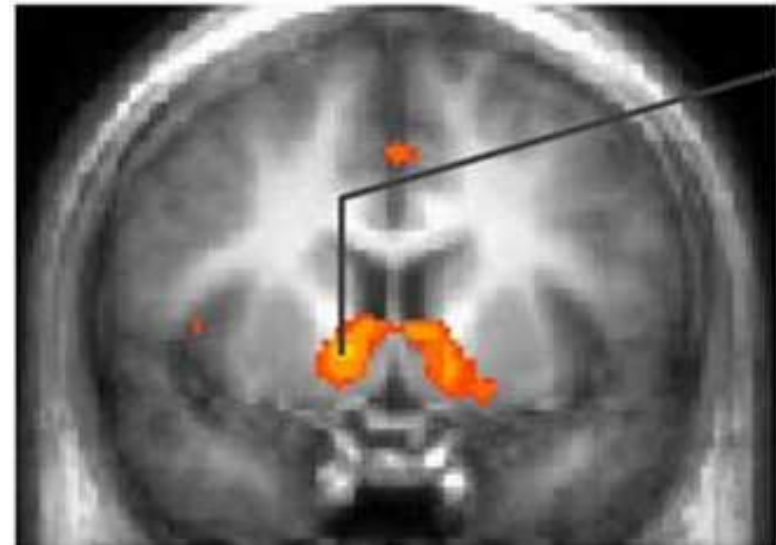
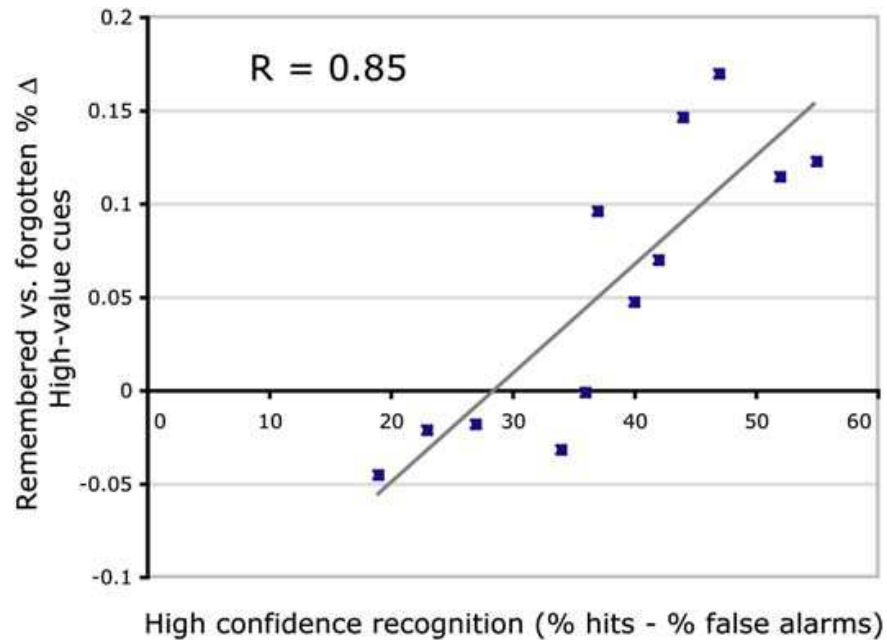
Major study found that incentives made some pupils work harder in class but had no impact on exam performance



The study offered pupils incentives if they met targets for homework, attendance, behaviour and classwork.



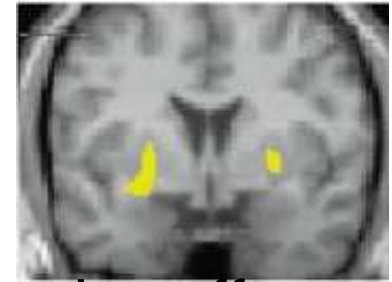
# Reward response predicts declarative memory ...



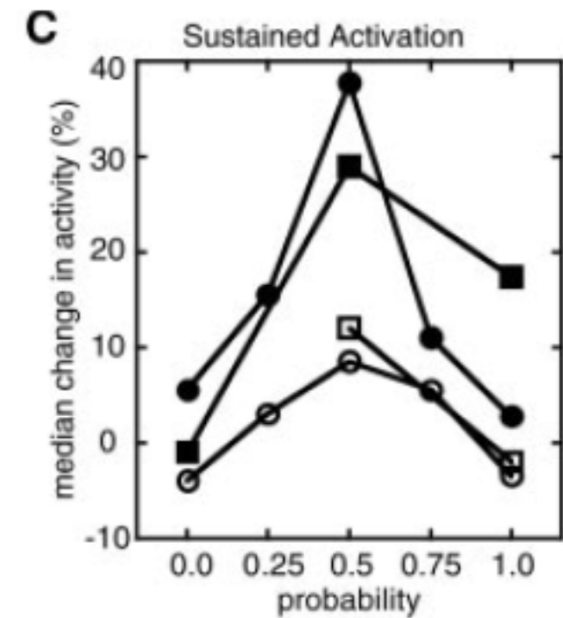
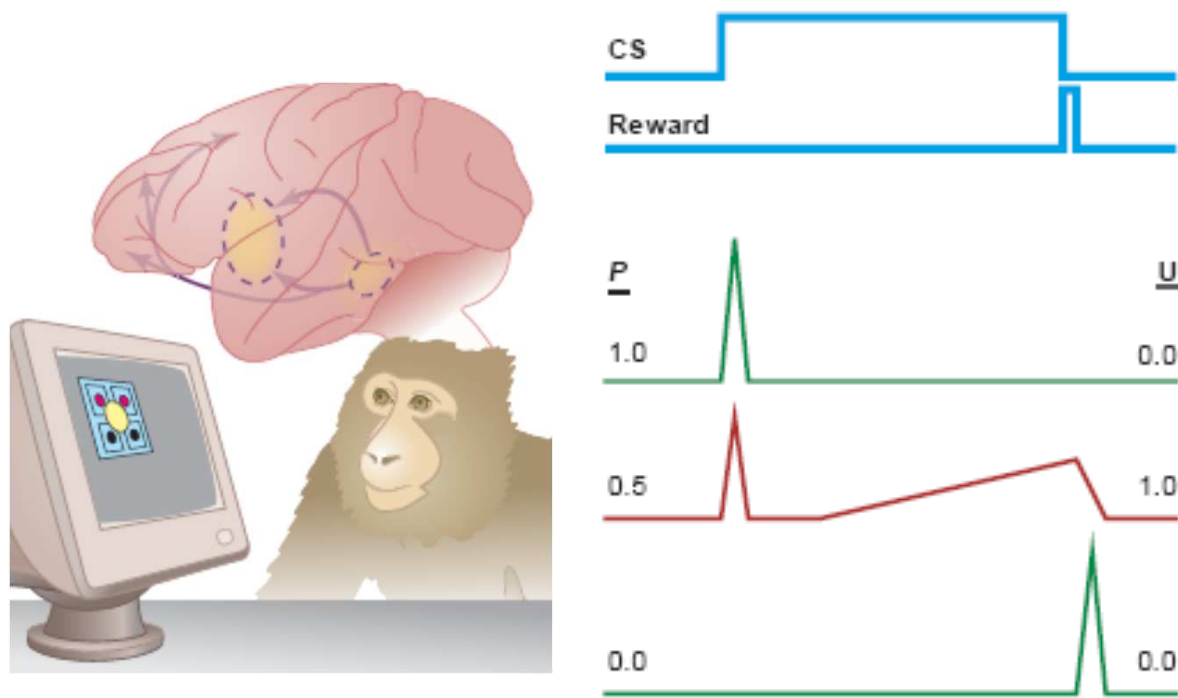
Adcock, R. A. (2006). "Reward-motivated learning: mesolimbic activation precedes memory formation." *Neuron* 50(3): 507-517.

# Games stimulate the brain's reward system

- Rapid schedule of rewards stimulates midbrain regions (Koepp et al., 1998)
- Significant dopamine release comparable to the effects of psychostimulant drugs (Weinstein, 2010)
- If you apply DSM addiction criteria, 1 in 5 teens addicted in '98 (Griffiths et al., 1998)
- Game rewards are uncertain

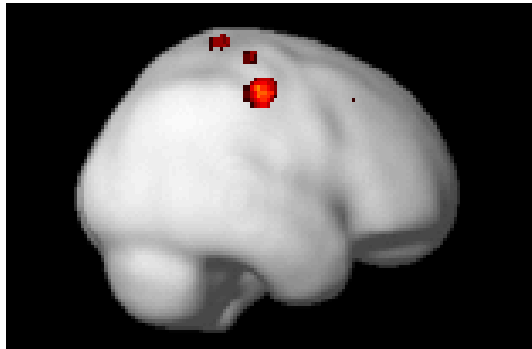


When reward is 50:50 uncertain, it generates maximum dopamine in the reward system:



C. D. Fiorillo et al, (2003).

# Types of research



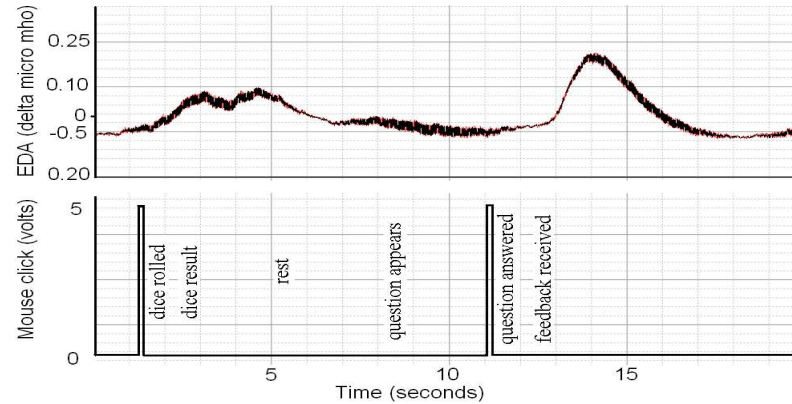
Scientific Study: Neurocomputational modelling

*Our competitor's losses are our rewards*



Practice-based studies: Action research

*Pedagogic guidelines*



Bridging study: skin (emotional) response

*Gaming transforms emotionality of learning*



**F1R: Shall we play again?**

**F1L: So annoying....**

**F1R: Don't mind ....shall we?**

**F1L: Yeah, roll the dice...**

Bridging study: Discourse analysis

*Motivational sport-talk, losses as fair*



Classroom studies suggest uncertain reward is more effective (Devonshire et al., 2014, Ozcelik et al., 2013)

Our popular app is being used in over 20 countries.

# Does “gamification” boost engagement and educational learning?

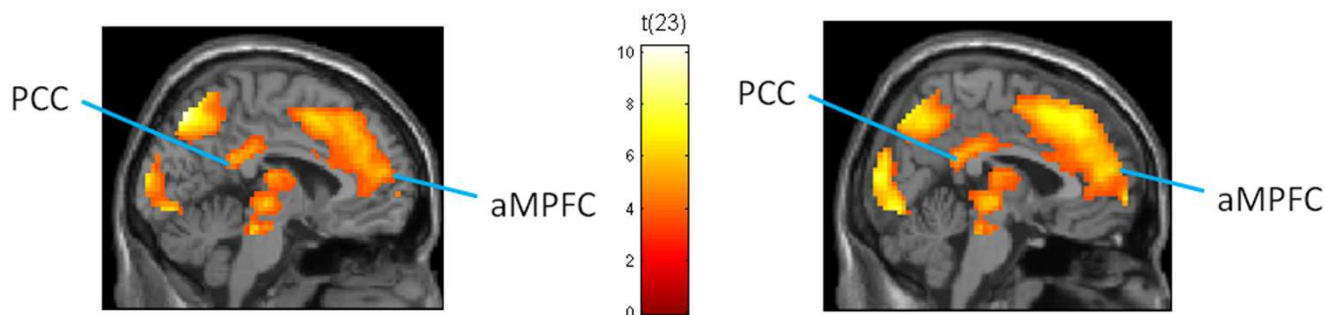


- 80 schools
- Comparing game-based, test-based and “usual” teaching of science from 12-13 yrs
- 10,000 children

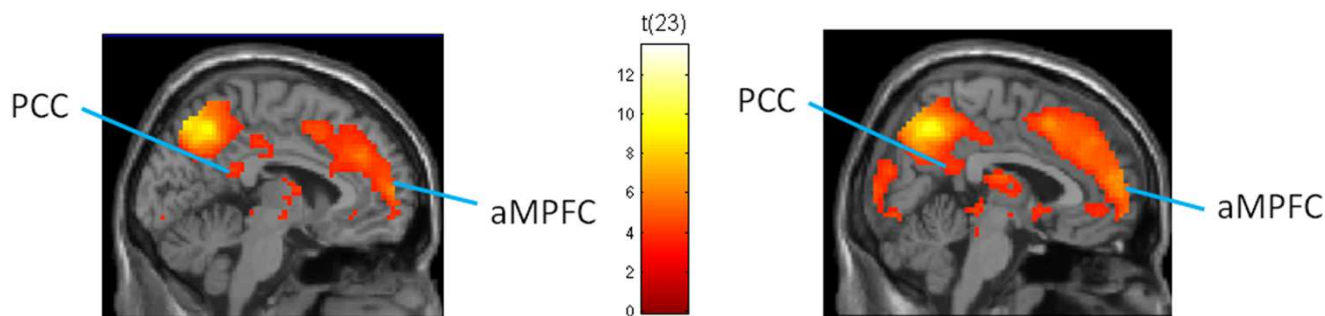


Adult fMRI study (in press):  
During study, massive deactivation of the Default Mode Network  
(mind-wandering) with increasing “gamification”

Game-based vs. Study-only



Game-based vs. Self-quizzing

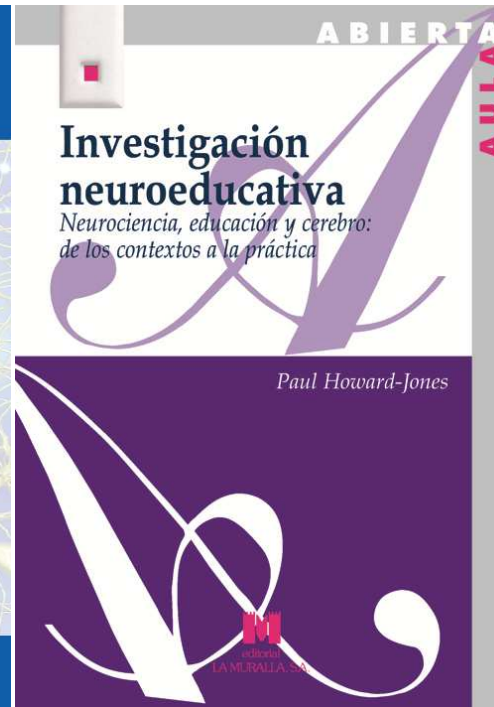
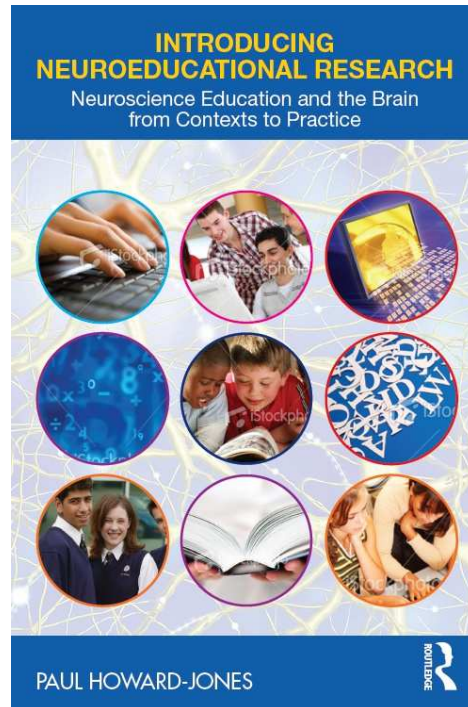


LEFT

RIGHT

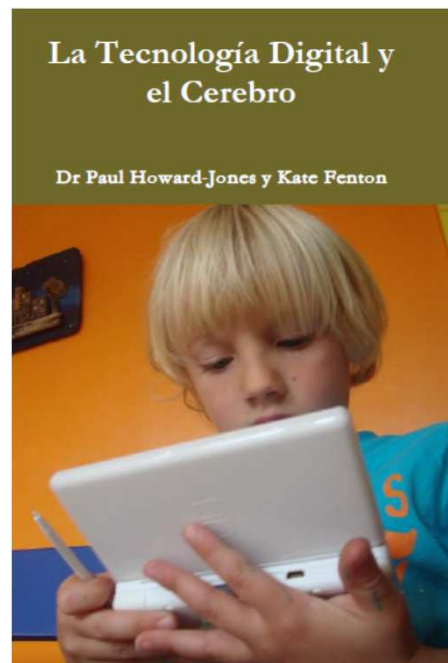
(Image thresholded at  $p < 0.001$ , 10 voxels extent)

Game-based vs Study-only deactivation of L/R PCC correlated with Game-based vs Study-only learning differences across individuals (as measured on leaving scanner).



- “Introducing Neuroeducational Research”
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- Paperback
- Published by: Routledge. And La Muralla (Madrid)

Thanks for listening! 😊



**La tecnología digital y el cerebro(2012)**  
Paul Howard-Jones and Kate Fenton  
5 euros!

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