



Working memory in the classroom: linking research and practice

Susan Gathercole

MRC Cognition and Brain Sciences Unit, Cambridge

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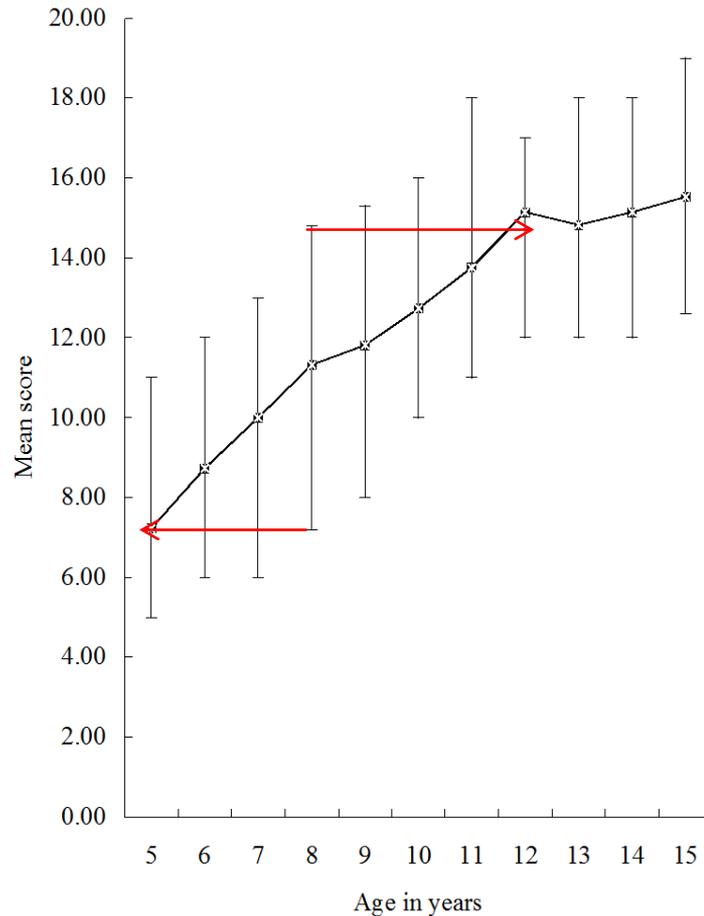
Key features of working memory

- Capacity to hold material in mind and manipulate as necessary for brief period
 - *Take the first right, second left after the lights, directly opposite the church*
 - *Put your sheets on the green table, arrow cards in the packet, put your pencil away and come and sit on the carpet.*
 - *Multiple 153 by 262*
- Mental workspace
- Limited in capacity
- Catastrophic loss

Why is WM important for classroom learning?

- Many children have poor WM capacities:
 - Reading difficulties, maths difficulties, language impairment, ADHD

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



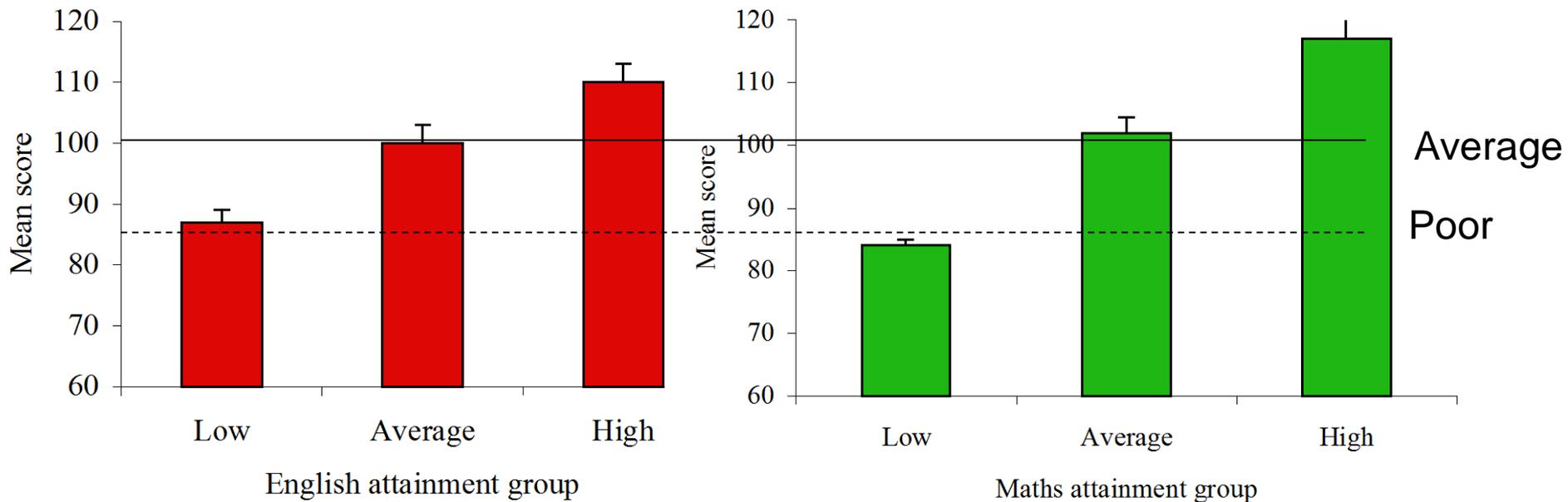
Why is WM important for classroom learning?

- Many children have poor WM capacities
- WM abilities are closely linked with learning:

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)

Gathercole et al. (2004):

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



Classroom problems faced by children with low WM

- 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.

Failures typically involve starting to perform instructions but failing to complete.

The children know that they have forgotten

Classroom problems faced by children with low WM

- Difficulties in following instructions
- Place-keeping difficulties

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: *moNemarket*.

Classroom problems faced by children with low WM

- Difficulties in following instructions
- Place-keeping difficulties
- Teachers say: short attention span and 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"

Classroom problems faced by children with low WM

- Difficulties in following instructions
- Place-keeping difficulties
- Teachers say: short attention span and distractible

Why do these children struggle to learn?

- Fail to meet the working memory demands of many structured classroom activities
- Leads to failure/ task abandonment
- Lost learning opportunities slow rate of learning

WM challenges for older children and learners

- Problems typically do not diminish with age, but the challenges change
- Lecture-based delivery, note-taking, speed of transmission of information
- Integration of multiple information sources for coursework
- Revision
- Essay planning

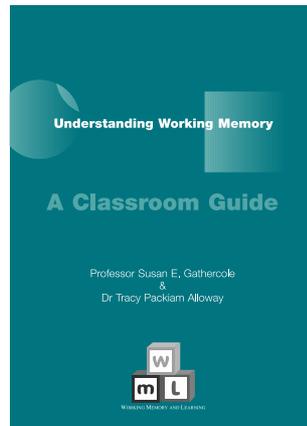
Two challenges

- How can we improve the classroom environment to reduce WM overload?
- How can we improve WM capacity?

1. Managing WM loads in the classroom (with J Elliot, Durham)

Developed a support programme for teachers and TAs:

- Introductory workshop and materials
- Screening for low WM children
- Guidance on how to avoid WM overload



Working Memory & Learning

A Practical Guide for Teachers

Susan E. Gathercole & Tracy Packiam Alloway



Classroom support: Principles

- **Be aware of the warning signs of WM failure**
 - Incomplete recall
 - Failing to follow instructions
 - Losing track of place
 - Abandoning the task

Classroom support: Principles

- Be aware of the warning signs of working memory failure
- **Reduce amount and complexity of information to be stored**

Classroom support: Principles

- Be aware of the warning signs of working memory failure
- Reduce amount and complexity of information to be stored
- **Help the child access forgotten information:**
 - repetition
 - prompts: diagrams help
 - audio recorders
 - team-working
 - giving the child permission to ask

Classroom support: Principles

- Be aware of the warning signs of working memory failure
- Reduce amount and complexity of information to be stored
- Help the child access forgotten information
- **Encourage the use of memory aids:**
 - reduce visual clutter
 - bespoke, individualised
 - highly practiced
 - to hand

Classroom support: Principles

- Be aware of the warning signs of working memory failure
- Reduce amount and complexity of information to be stored
- Help the child access forgotten information
- Encourage the use of memory aids
- **Help the child to use strategies**

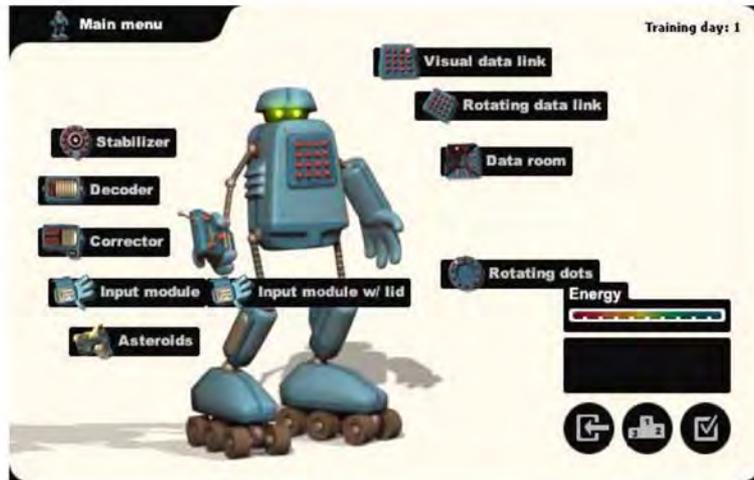
Classroom support: Principles

- Be aware of the warning signs of working memory failure
- Reduce amount and complexity of information to be stored
- Help the child access forgotten information
- Encourage the use of memory aids
- Help the child to use strategies
- **In older children, online support**

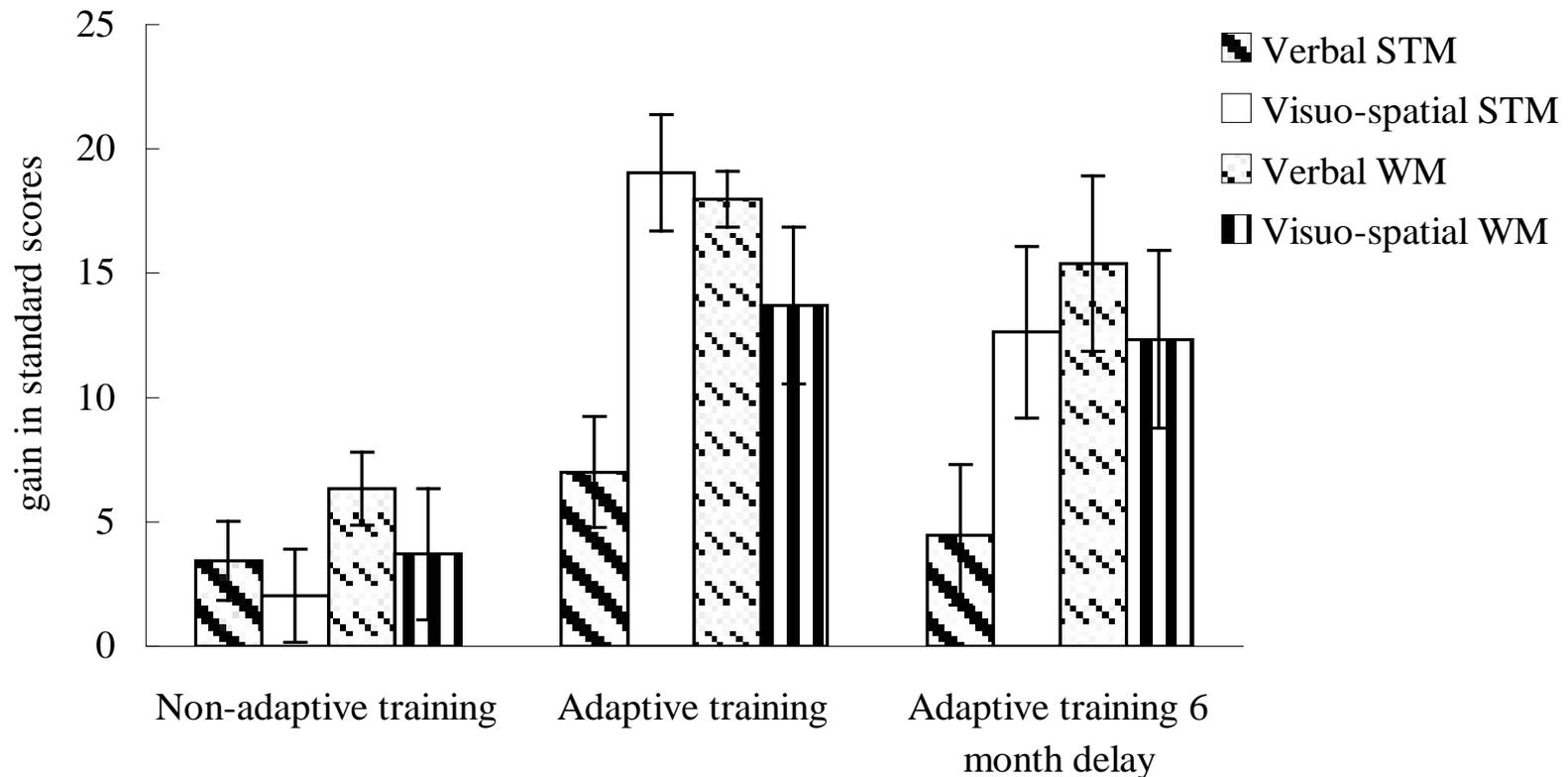
2. Improving WM: can it be done?

Cogmed

- Adaptive
- 8 tasks/115 trials per session
- 20-25 sessions



Cogmed training in children with poor WM (Holmes et al., 2009): mean gains in WM scores

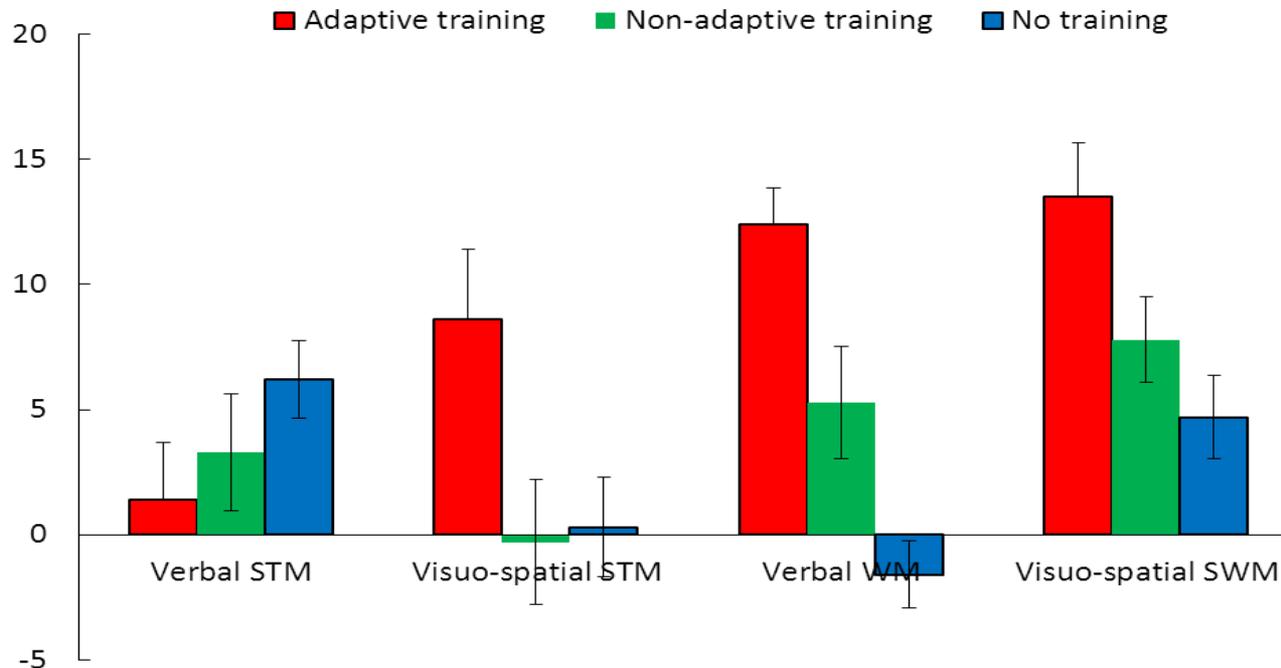


Ability to follow instructions improved

No changes in IQ or reading

Significant improvements in maths scores after 6 months

RCT of Cogmed training in low WM children (Dunning et al., 2013: Mean gains in WM scores

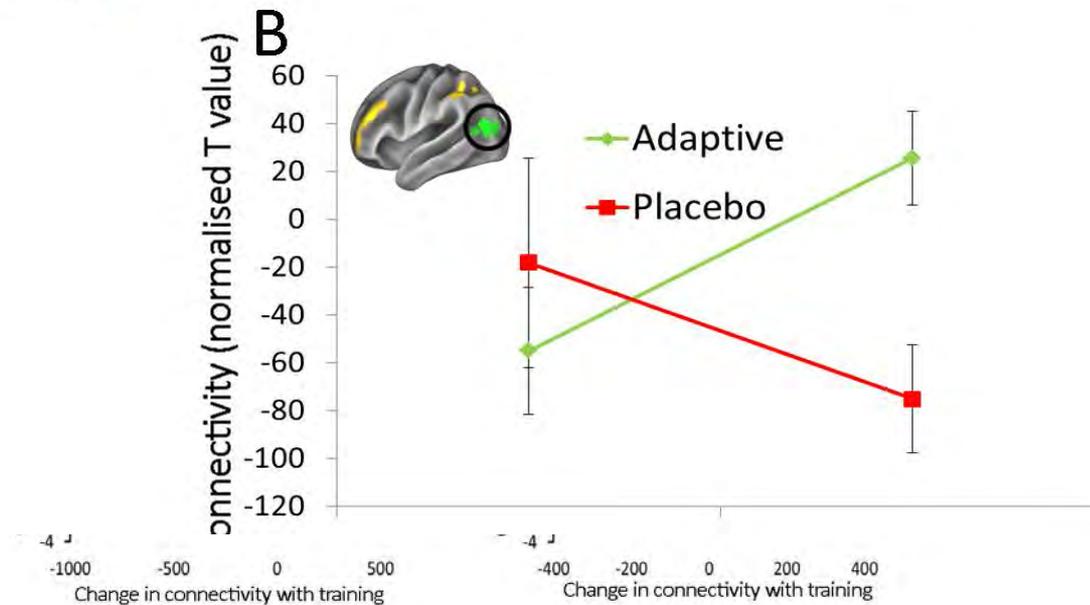
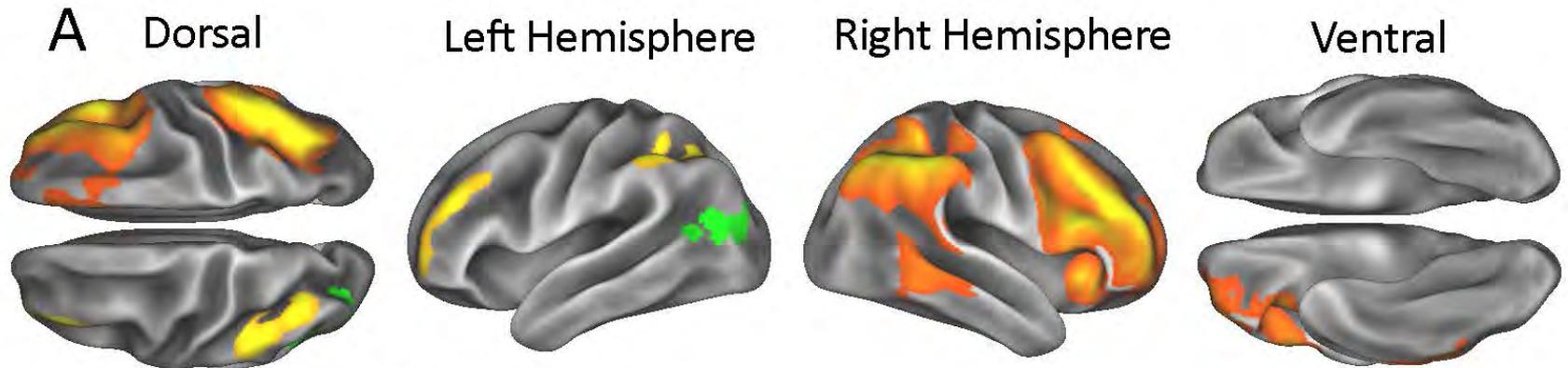


Improvements in verbal WM persisted 12 months after training

But:

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

What changes take place in the child's brain following training? Duncan Astle & Jessica Barnes



How can we make WM training effective?

- ***by narrowing the transfer gap:*** embed training in educational activities that depend on WM
- ***learn lessons from other fields of intervention:***
 - i) metacognitive awareness
 - ii) extensive practice following training in applying strategies to everyday activities

Embedding WM training in maths

Joni Holmes, Darren Dunning, Graham Hitch

Maths training

WM
load

Mental arithmetic

$$2+4, 5+3$$

$$8+5, 6+7$$

$$39+84, 46+75$$

Mathematical reasoning

Neil had five marbles. Then his mother gave him three more. How many marbles did he have then?

Eleven ducks were swimming in a pond. Three flew away. How many ducks were in the pond?

Erik had four pounds seventy-two pence on Monday. On Tuesday he earned two pounds fifty pence mowing the lawn. On Thursday he spent three pounds and eleven pence at the cinema. How much money did he have left?

Following instruction training

classroom

school

WM
load



Pick up the globe

Move the stapler to the bookcase, then
pick up the paper

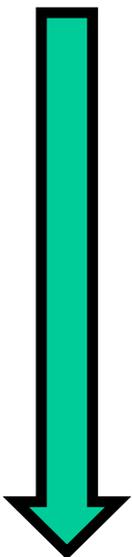
Pick up the red book, then move the
pen to the whiteboard, then pick up
the headphones



Go to the Hall and move the ball to the door

Go to Mr Taylor's room and pick up the pencil, then go to Mrs
Bolton's room and move the globe to the desk

Go to the IT suite and pick up the mouse, then go to Miss Smith's
room and pick up the keyboard, then go to Mrs Bolton's room and
move the stapler to the drawer



Embedding WM training in maths activities

Joni Holmes, Darren Dunning, Graham Hitch

Abilities trained

- Mental arithmetic
- Mathematical reasoning
- Following instructions

Metacognitive support for training

Strategy development and awareness training

Extension activities

Puzzles, classroom analogue activities, ...

Online trainer support

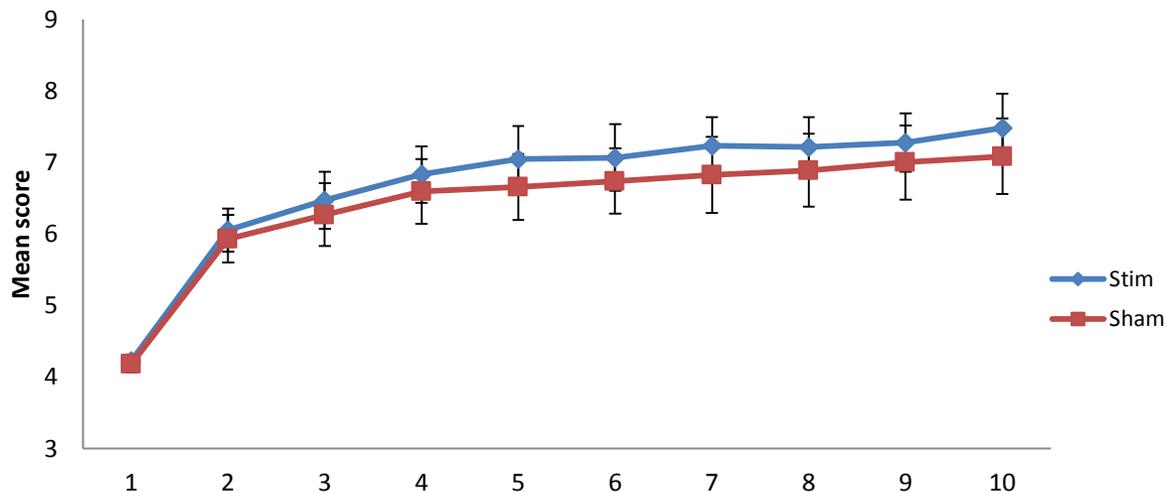
Technical manuals, e-learning, non-specialist guidance materials & publications

Using brain stimulation to enhance the effects of WM training

- Neurostimulation (tES) uses a weak electric current to stimulate a brain area of interest
- Boosts performance on WM tasks
- Enhances intervention outcomes when combined with cognitive training
 - Maths training (Cohen Kadosh et al., 2010)
- Neuro-modulator, not a neuro stimulator
 - induces a state like 'wet clay'
 - persistent increase in the synaptic strength between two activated neurons, enabling neuroplasticity

Can we improve training gains by stimulating the brain? Joni Holmes, Michael Ewbank & Elizabeth Byrne

tES with Cogmed WM training in healthy adults
Average progress across trained tasks:



Preliminary evidence that the transfer distance (spread of gains over WM tasks with different structures) increases with stimulation

Summary

- Many children fail to meet the WM loads of classroom activities, and this may impair learning
- The classroom needs to be designed to avoid unnecessary WM overload
- Learners should be equipped with strategies to help compensate for low WM capacity.
- Intensive training does have benefits for WM performance and changes neural functioning, but to date they have not extended to practical aspects of learning.
- New interventions are urgently required that embed training in practical situations to boost benefit for everyday function and learning.

A combination of approaches may be optimal

classroom management
+ strategy training
+ embedded WM training
+ brain stimulation???



Contact



Email: susan.gathercole@mrc-cbu.cam.ac.uk

Centre for Attention, Learning & Memory

<http://www.mrc-cbu.cam.ac.uk/centre-for-attention-learning-and-memory-calm/>

Research Clinic for children with problems in attention, learning and memory.

Examples of heavy WM loads

- Remembering such sequences as
 - Three or more numbers (e.g., 5, 9, 2, 6)
 - Three or more unrelated words (e.g., *cat, lion, kangaroo*)
- Writing lengthy sentences containing some arbitrary content
 - (e.g., *To blow up parliament, Guy Fawkes had 36 barrels of gunpowder*)
- Following lengthy instructions
 - (e.g., *Put your sheets on the green table, arrow cards in the packet, put your pencil away, and come and sit on the carpet*);
- Keeping track of the place reached in the course of multi-level tasks
 - e.g., writing a sentence either from memory or copying from the board