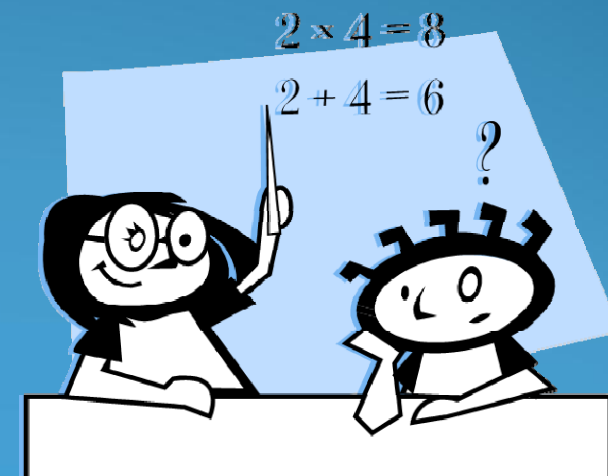


Understanding the role of metacognition and working memory in maths achievement

Dr Emma Walker

Co-Authors: Dr Julie Hadwin & Dr Helen Richards



Background

- Global economic crisis has led to a rise in unemployment, especially in the youth job market
- Wolf report on vocational education (2011) - formal maths qualification used as sifting criteria for course places and jobs
- Every Child A Chance (2009) – maths qualification increases earning potential
- DFE (2010) Low achievement in maths in primary school persists until end of secondary school

Theoretical model

Butterworth, Varma and Laurillard (2011)

- Model suggests the influence of learning experiences on:
- Biological factors: brain areas related to maths
- Cognitive factors: memory and some metacognitive processes
- Behavioural: performance on maths tasks

Demetriou, Christou, Spandoudis and Platsidou (2002)

- Model more specifically highlighted the role of metacognition in problem solving
- Proposed that working memory provides the 'cognitive space' for the execution of metacognitive processes

Definitions

- Working Memory = a limited storage control system that coordinates verbal and visuospatial material and manages the transfer of information in and out of long term memory (LTM) (Baddeley & Hitch, 1974).
- Metacognition = Monitoring the application of cognitive strategies (Flavell, 1979)
 1. Metacognitive knowledge
 2. Regulation of cognition

Maths and Working Memory training/Metacognition interventions

Working Memory Training

- Working memory training studies show improved maths achievement (e.g. Alloway, 2012; Holmes et al., 2009)
- Very new research area

Metacognition Interventions

- Metacognition trained in the context of a maths lesson
- Research shows improvements in maths achievement (Kramarski & Mizrachi, 2006; Verschaffel et al., 2009)

Anxiety

- Maths anxiety is proposed to affect performance on maths tasks (Ashcraft & Kirk, 2001)
- Anxious thoughts (worries) occupy cognitive 'space', thus lowering WM capacity (Eysenck & Calvo, 1992) leaving less 'space' to process maths information.
- Anxiety can impair MC because if an individual has a high level of maths anxiety they are unable to use their MC knowledge when completing a maths task and thus perform poorly (Veenman, Kerseboom & Imthorn, 2000)

Aims and hypotheses

- Novel contribution: To measure both Working Memory and Metacognition in interventions focused on achieving change in maths achievement.
- Explored intervention's effect on anxiety and whether this was linked to maths achievement.
- Objective was to inform future maths interventions
- Following previous research, it was anticipated that pupils in both groups would improve their maths scores but that this would be achieved via change in different underlying mechanisms.
- If interventions increased participants' maths achievement this should be associated with decrease in maths anxiety.

Method

Participants

- 13-14 years old
- Underachieving in maths

Measures

- Wide Ranging Achievement Test (4) – maths subtest (Wilkinson & Robertson, 2006)
- Automated Working Memory Assessment (Alloway, 2007)
- Junior Metacognitive Awareness Inventory (Sperling, Howard, Miller & Murphy, 2002).
- Abbreviated Maths Anxiety Questionnaire Hopko, Mahadevan, Bare & Hunt, 2003).
- Spence Children's Anxiety Scale (Generalised Anxiety items) (Spence, 1998)

Method

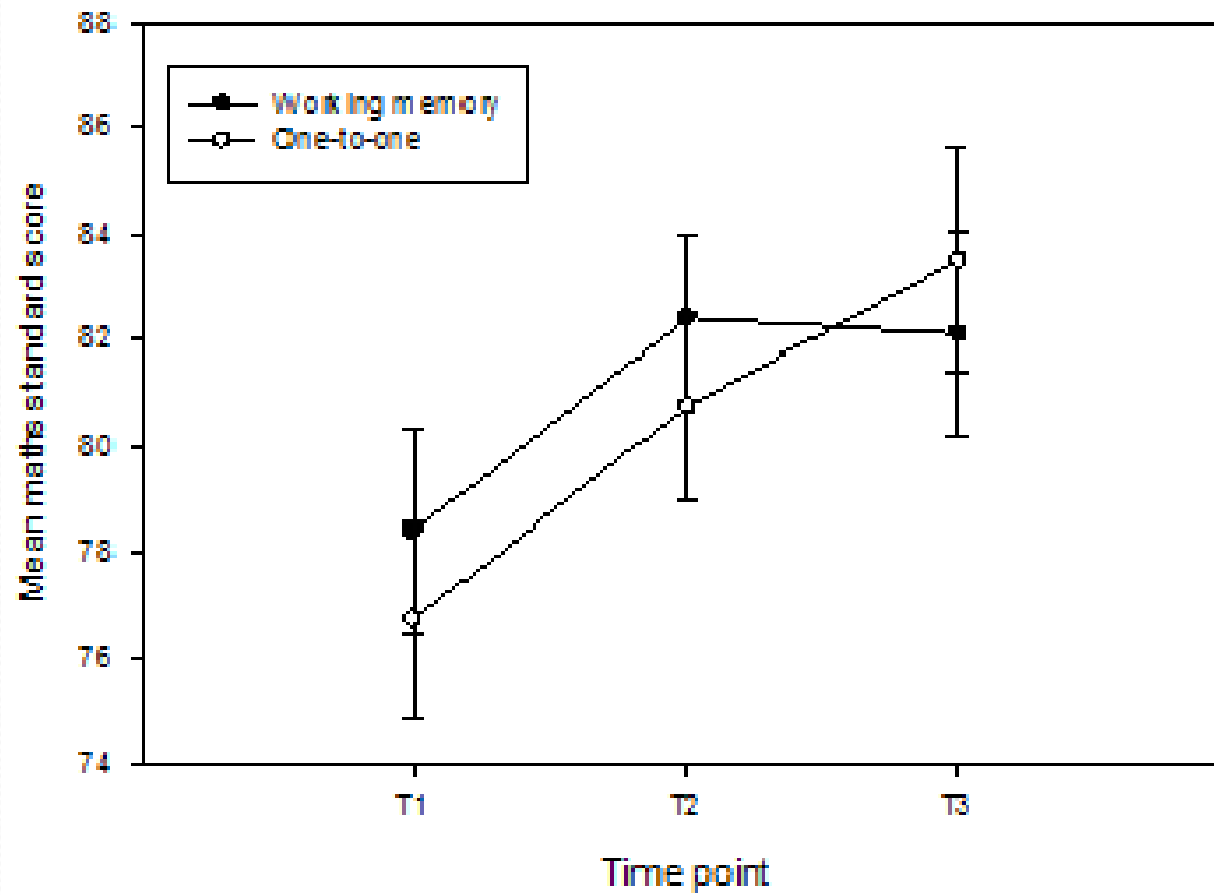
Procedure

- Pre-test in July 2012
- Matched pairs based on T1 maths scores – then randomised to intervention
- CogMed and One to One tutoring delivered to two cohorts
- Post test
- Follow-up 8 weeks later

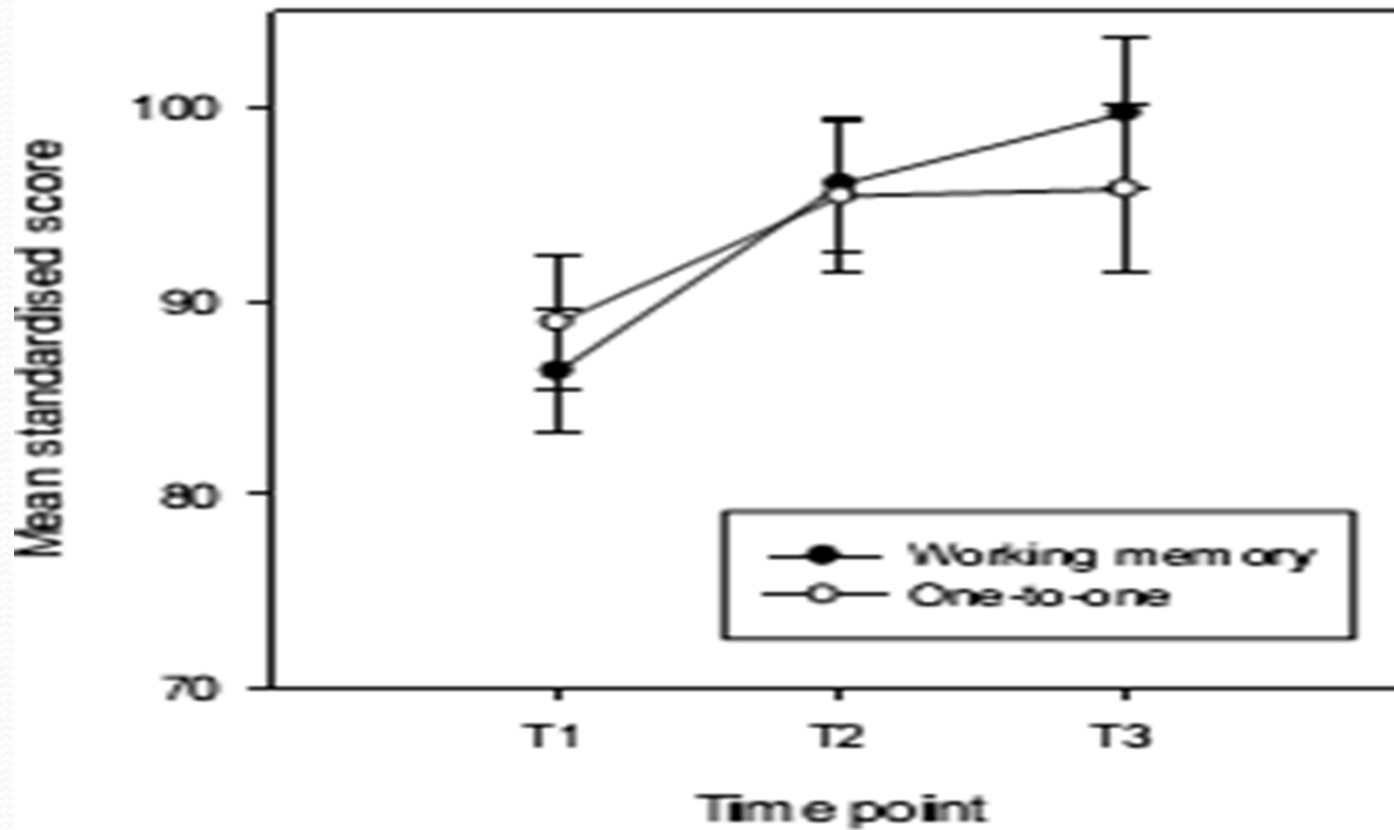
Analysis

- An independent samples t-test on all T1 data indicated no significant differences between scores on any measure with all ts <1.5 and all ps > .1.
- In addition to considering statistical significance Effect Sizes (ES) as measured by Partial Eta Squared were reported as small (>.01), medium (>.06) and large (>.14) (Richardson, 2011)
- Individual reliable change measures (Jacobson & Truax, 1991)

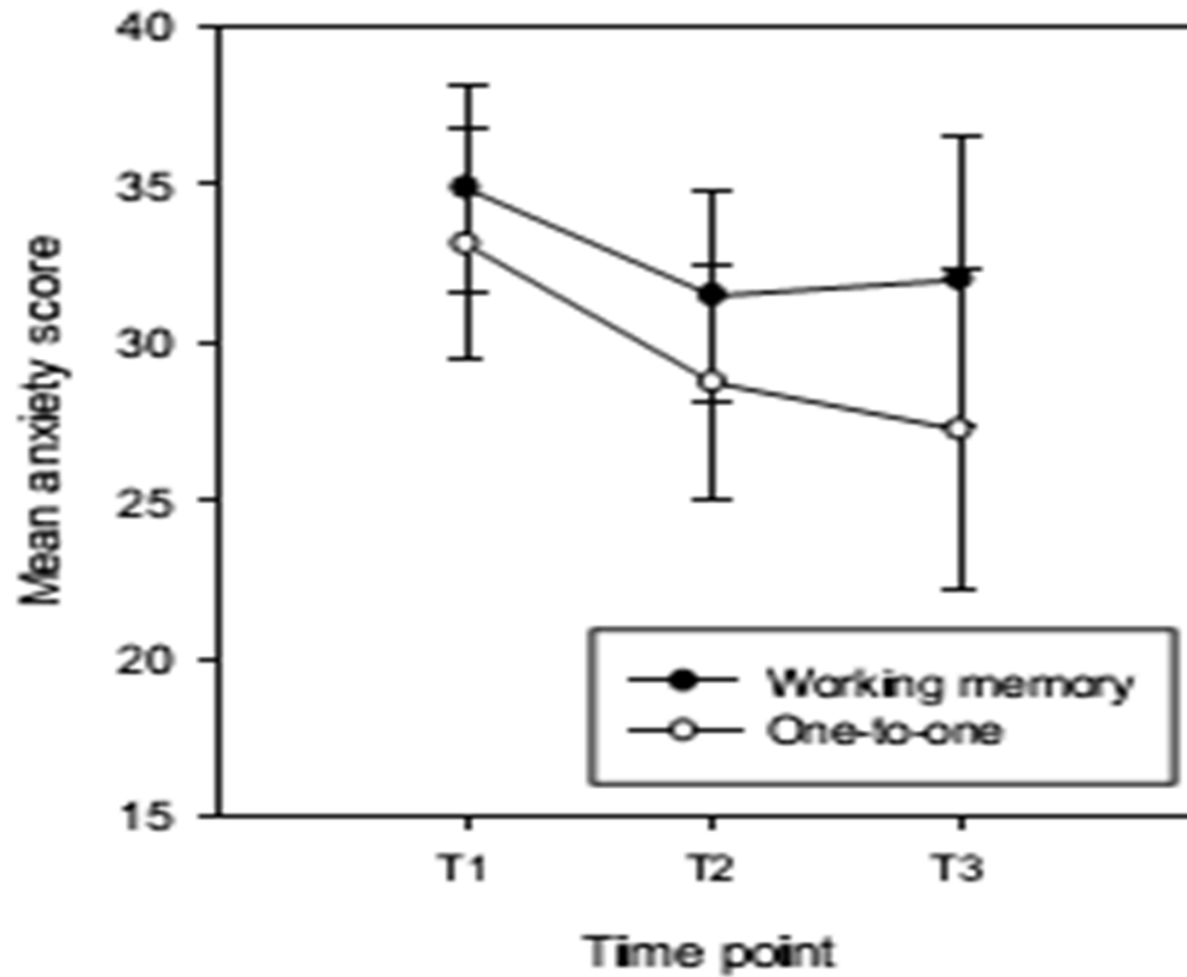
Results: Maths



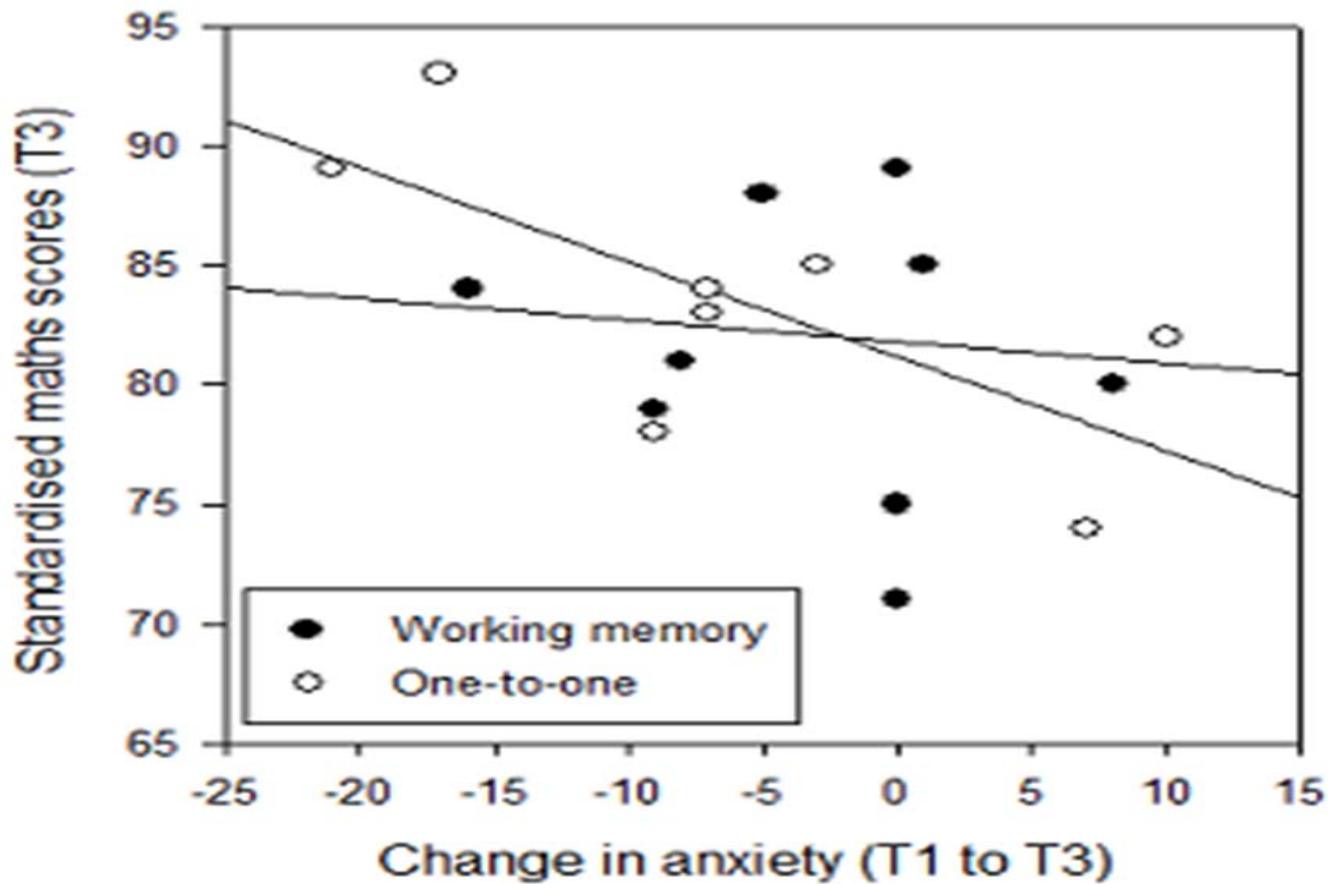
Results: Working Memory



Results: Anxiety



Understanding change: The link of maths and anxiety



Discussion

CogMed and One to One tutoring

Significant improvements in:

- Maths achievement
- Working memory

Significant reduction in :

- Anxiety

No significant change in:

- Metacognition

Maths Improvement in CogMed

- Consistent with previous research (e.g. Holmes et al, 2009)
- No direct link found between maths achievement and working memory

Maths Improvement in One to One tutoring

- Self-regulation - motivation (Eshel & Kovi, 2007; Luo et al., 2011)
- Teacher focus (Chui, 2004).

Anxiety reduction and improved maths scores

- Cognitive capacity no longer occupied by anxious thoughts (Eysenck & Calvo, 1992; Eysenck et al., 2007)

Limitations

- Small sample size
- Lack of blinding
- No passive control group (the two experimental groups were effectively active controls for each other)
- Metacognition measure not sensitive enough or perhaps needed to be domain (maths) specific

Implications

- Demonstrated efficacy of interventions studied
- Empirical support for use of One to One tutoring

Future research

- Investigate the impact of factors such as self-efficacy and motivation
- Develop understanding of how anxiety is reduced

Future interventions

- Combine Working Memory and One to One tutoring to maximise improvements

Acknowledgements

- Secondary school staff and pupils at the participating school.
- Support from CogMed to use the training programme for the research project.