University of East Anglia

MRC Cognition and Brain Sciences Unit

# Does working memory training lead to generalised gains in children with a traumatic brain injury?

Darren Dunning

# What is Traumatic Brain Injury (TBI)?

- A TBI is any brain injury caused by an external force
- It is the most common Acquired Brain Injury (ABI)
  - ABI includes stroke, encephalitis, tumour, etc.
- TBI is a leading cause of death by accident with 50,000 fatalities per year in the US
  - 2.5 million TBIs per year

# What is Traumatic Brain Injury (TBI)?

- The severity of TBIs varies
  - mild
  - moderate
  - Severe

- Long-term outcome for those that have had a mild injury is relatively good (e.g. Carroll, et al., 2004).

- More Severe injuries often lead to
  - emotional problems (e.g. aggression, depression, etc.)
  - cognitive deficits in memory and attention

# Meta-analysis

(Dunning, Westgate & Adlam, in prep)

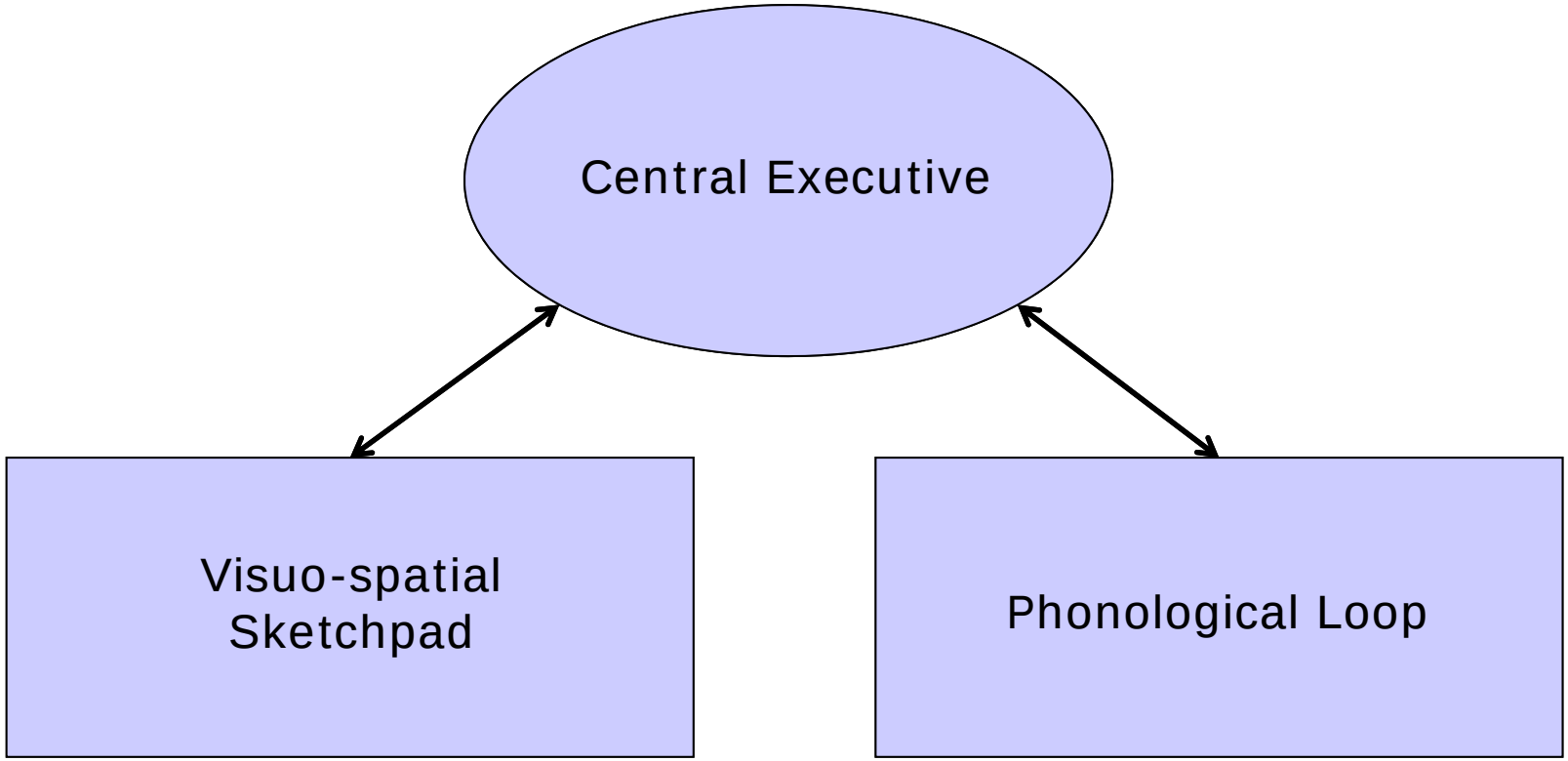
- Conducted a meta-analysis of WM and TBI because:
  - Many studies that have looked at WM and TBI are by clinicians and have small samples
  - Studies often conflate measures of STM with WM
  - Many studies do not include 'healthy' comparison groups
  - WM not a unitary system, but consists of multiple interacting subcomponents that contribute differentially to different WM tasks. No one had looked at these WM subcomponents in detail in a TBI group

# Literature search

- Inclusion criteria:
  - Moderate/severe TBI
  - The study used at least one measure of WM or STM
  - The study compared its TBI group against a healthy-aged matched comparison group

- 17 studies included

# A Model of Working Memory




*Baddeley & Hitch (1974)*

# Results

*Table 1. Meta-analyses of working memory components between individuals that have survived a traumatic brain injury and normal controls*

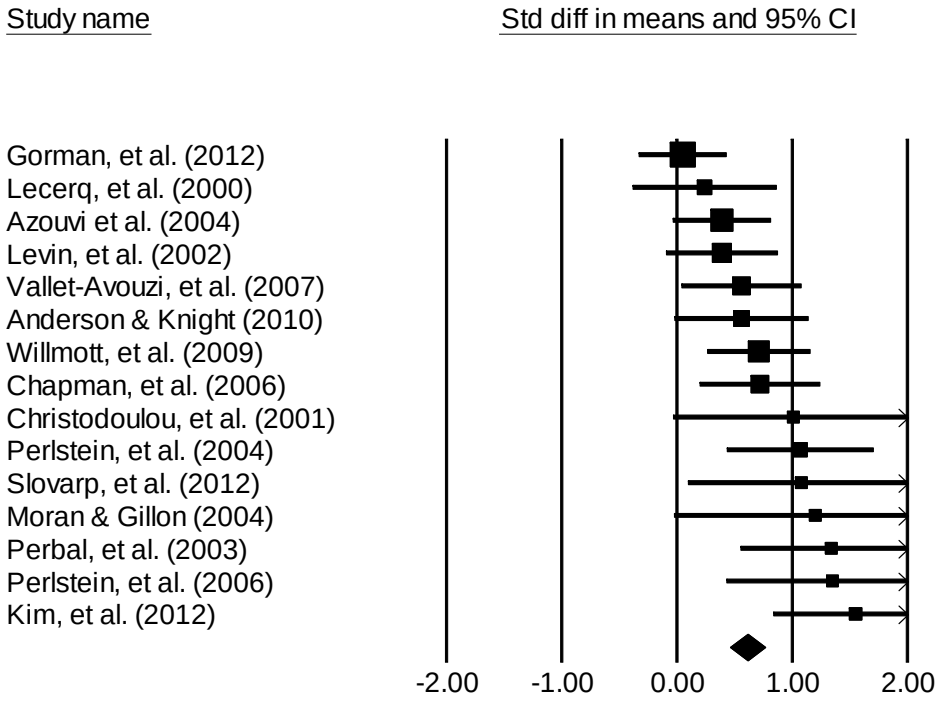
| | No. of studies | No. of subjects | | Mean effect size (d) | z | 95% CI | $I^2$ (95% CI) |
|---|---|---|---|---|---|---|---|
| | | TBI | HC | | | | |
| Verbal STM | 8 | 270 | 238 | 0.41 | 3.96* | [0.21 - 0.57] | 17.52 |
| Visuo-spatial STM | 4 | 124 | 89 | 0.23 | 1.65 | [-0.04 - 0.51] | 0 |
| Verbal WM | 15 | 381 | 356 | 0.70 | 6.07* | [0.47 - 0.93] | 50.42 |
| Visuo-spatial WM | 4 | 188 | 128 | 0.60 | 1.92 | [0.31 - 0.77] | 83.97 |
| Short-term memory | 9 | 289 | 238 | 0.41 | 3.74* | [0.21 - 0.56] | 27.73 |
| Working memory | 16 | 451 | 396 | 0.69 | 6.89* | [0.49 - 0.77] | 42.61 |
| Verbal memory | 17 | 515 | 417 | 0.65 | 6.33* | [0.43 - 0.71] | 46.54 |
| Visuo-spatial memory | 5 | 194 | 129 | 0.47 | 3.53* | [0.21 - 0.74] | 18.50 |

*NB: TBI = traumatic brain injury; HC = healthy controls; CI = confidence intervals*

**p<.001*

NB: If a study used multiple measures of an aspect of memory, then effect sizes were averaged (e.g. For composite WM all WM tasks were averaged regardless of if the were verbal or visuo-spatial)

# Meta-regression



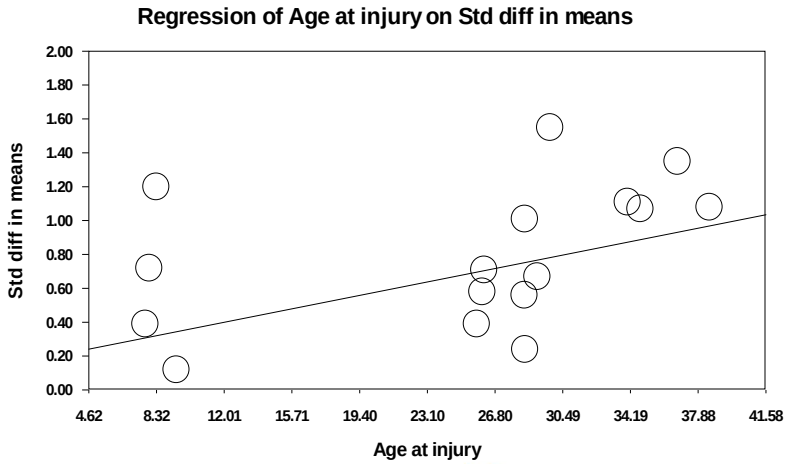
# Meta-regression

- To explore differences in effect sizes, two moderator variables were examined :
  - Time since TBI
  - Age TBI occurred

# Results

- WM v STM for **age at Injury**

Working Memory (p= <.01)

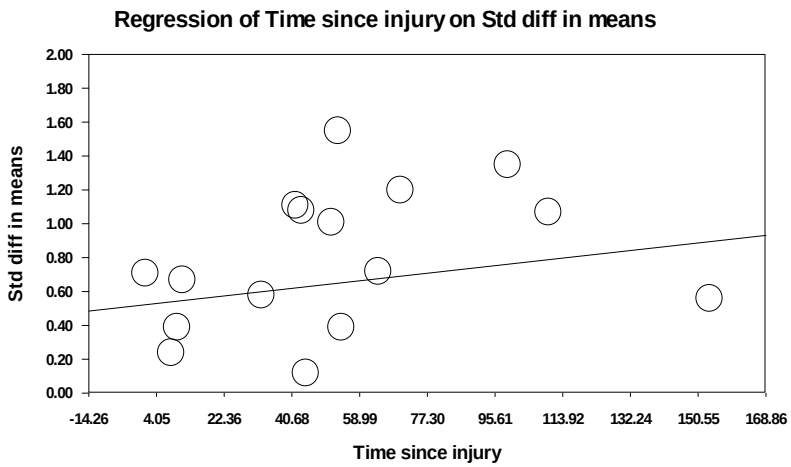



Short-term memory (p=.80)

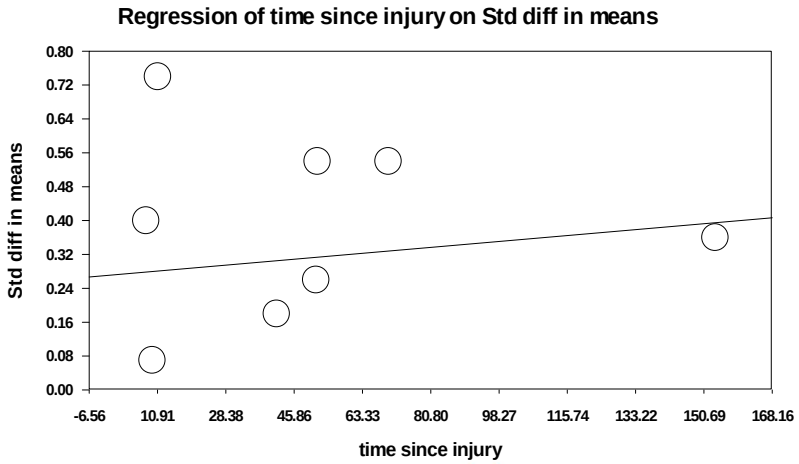
# Results

- WM v STM for **time since injury**

Working Memory (p= .20)




Short-term memory (p=.20)



# Interim conclusions

- TBI individuals have pronounced deficits in WM when compared to healthy, age-matched controls.
- Deficits in STM less pronounced
- In TBI individuals, deficits in WM (but not STM) are greater when the TBI occurs at an older age.
- Deficits in verbal abilities greater when TBI occurs at an older age.
- Why?
  - STM v WM – WM more attentionally demanding?

# Rationale for RCT

- Children that have survived a TBI often have cognitive impairments including WM deficits that impact on their schooling.
- No previous Cogmed studies with TBI individuals or brain injured children.

| | Yr | Sample | Control group? | Gains? |
|---|---|---|---|---|
| Björkdahl, et al. | 2013 | 20 adults (ABI) | ✓ 18 | Digit span, rivermead<br>NB: no improvement on BDR |
| Johansson & Tornmalm | 2012 | 18 adults (ABI) | X | Trained tasks |
| Lundqvist, et al. | 2010 | 11 adults (ABI) | ✓ 10 | Trained tasks, neuro WM task |
| Westerberg, et al. | 2007 | 9 adults (stroke) | ✓ 9 | Span board |

# An RCT of Working Memory Training in children with TBI

- 90 Children aged between 8 – 16 years: 11 months
  - Moderate-severe TBI
  - 6 months post injury

- Exclusion criteria
  - Evidence of motor/ visual impairment
  - Use of medication affecting memory
  - Premorbid diagnosis of learning disability
  - Previous WM training
  - Lacks the capacity to assent/ consent

# The children are referred to us from one of the following sites

- Addenbrookes'
- Cambridge Centre for Paediatric Neuropsychological Rehabilitation
- Norfolk & Norwich Hospital
- West Suffolk Hospital
- Child Brain Injury Trust
- Frenchay Hospital
- Royal Devon & Exeter Hospital
- Cambridgeshire Community Services
- Norfolk & Waveney

# Design

- Children are screened on IQ and two tests of working memory. If they score in the bottom 30$^{th}$ centile on one of the working memory measures then they can be included in the study.

- Children are then assessed on an extensive range of measures of learning, behaviour, etc.

- Allocated to group (stratified by age and IQ)
    - Active intervention (adaptive working memory training)
    - Active control (non-adaptive working memory training)

However...

# An RCT of Working Memory Training in children with ~~TBI~~ ABI

- 29 children screened
  - 16 children trained:
    - 10 adaptive training
    - 6 non-adaptive training
  - 6 currently training
  - 3 waiting to train (undergoing pre-assessment)
  - 2 dropped out after screening
  - 2 did not meet inclusion criteria

# Trial updates

- Baseline data entered for first 22 participants
  - 15 boys, 7 girls
  - Mean age 12yrs, 3mths
- Mean deficits in:
  - Performance IQ (but not verbal IQ)
  - Short-term memory
  - Working memory (AWMA, BRIEF)
  - Long-term memory (Rey, CMS)
  - Attention (dual task)
  - Switching (letter-number)
  - Mathematics (but not reading comprehension)

# Trial updates

- Mean deficits in (contd):
  - Inattention
  - Hyperactivity
  - Executive functions
  - Learning
  - Aggression
  - Peer problems
  - Inhibition
  - Emotional control
  - Initiate
  - Planning
  - Organisation of materials
  - Monitoring

# Some notes on those that have trained

- Training is taking longer than expected, especially for the adaptive condition
    - Average 9 weeks for adaptive condition
        - Shortest 5 weeks, Longest 20 weeks
    - Average 7.8 weeks for non-adaptive condition
        - Shortest 5 weeks, Longest 13 weeks

- Average gain is 19 points on Cogmed index
        - Average in US for children aged 7-17 is 28

# Conclusion

- So far there has been difficulty recruiting a childhood TBI group
- In this very early stage of data collection no group differences on the memory measures
- It is taking longer for the brain injured children to complete Cogmed and their gains are a little below what would be expected

Thanks for Listening

Questions?