Disorders of working memory: Causes and remediation

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WM: Key features

- Capacity to hold material in mind and manipulate as necessary for brief period
- Mental workspace
- Limited in capacity - varies between individuals
Children with low working memory

- Struggle at school because the working memory loads of individual learning activities are excessive
  - Fail to complete individual learning exercises
  - Over time, fail to accumulate knowledge and fall behind peers
WM and Developmental Disorders

- Deficits in WM are a common feature in many acquired and genetic developmental disorders of learning
  - ADHD (Martinussen & Tannock, 2006)
  - Reading difficulties (Swanson, 2003)
  - Mathematical difficulties (Geary et al., 2004)
  - Specific Language Impairment (Archibald & Gathercole, 2007)
  - Dyslexia (Jeffries & Everatt, 2003, 2004)
  - Down syndrome (Jarrold, Baddeley & Hewes, 1999)
  - Williams syndrome (Jarrold, Baddeley, Hewes & Phillips, 2001)

- Profiles of children with ADHD and reading difficulties are similar to those of children poor WM
Children with low WM and children with ADHD

- 7- to 11-yr old children with:
  1. ADHD ($n=83$, no meds)
  2. low WM ($n=50$)
  3. typical WM ($n=50$)

**Conners Teacher Behaviour Ratings**

**Attainment and IQ**

Holmes et al., in prep.
Working memory in ADHD and low WM

<table>
<thead>
<tr>
<th>Memory Type</th>
<th>ADHD</th>
<th>Low WM</th>
<th>Average WM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal STM</td>
<td>90±10</td>
<td>80±10</td>
<td>100±10</td>
</tr>
<tr>
<td>Visuo-spatial STM</td>
<td>110±10</td>
<td>90±10</td>
<td>120±10</td>
</tr>
<tr>
<td>Verbal WM</td>
<td>80±10</td>
<td>70±10</td>
<td>100±10</td>
</tr>
<tr>
<td>Visuo-spatial WM</td>
<td>90±10</td>
<td>80±10</td>
<td>110±10</td>
</tr>
</tbody>
</table>
Working memory in poor readers

- 22 poor readers aged 8 – 10 years
- 23 typical readers matched for NVIQ
Low WM, ADHD and reading difficulties

- Children with ADHD and those with low WM:
  i. poor learners
  ii. inattentive
  iii. verbal and visuo-spatial WM difficulties

- Children with ADHD are more likely to behave impulsively

- Poor readers also show i and ii, but have greater verbal than visuo-spatial impairments
Two important questions

1. Are the WM deficits so commonly observed a core feature of different disorders?

2. Does the cause of the WM difficulty limit response to interventions targeted at WM?
1. Are WM deficits core to the disorder?

Working memory in its broader context
Potential sources of WM deficits

Phonological/verbal impairments

WORKING MEMORY

- verbal STM
- visuo-spatial STM

EXECUTIVE FUNCTIONS

- WM executive control
- selective attention
- inhibitory control

Phonological inputs

Visuo-spatial inputs
Potential sources of WM deficits

WORKING MEMORY

phonological inputs

visuo-spatial inputs

verbal STM

visuo-spatial STM

EXECUTIVE FUNCTIONS

WM executive control

selective attention

inhibitory control

WM executive impairment
Potential sources of WM deficits

WORKING MEMORY

- verbal STM
- visuo-spatial STM

EXECUTIVE FUNCTIONS

- WM executive control
- selective attention
- inhibitory control

Cognitive control impairment

phonological inputs
visuo-spatial inputs

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Potential sources of WM deficits
2. Does cause limit response to intervention?

- Computerised training programs, target working memory
- Train on working memory tasks for 25 sessions over a 6-8 week period
- Adaptive: individual works at span level
Generalised effects of working memory training

RCT with children with poor WM (Dunning, Holmes & Gathercole, 2013)
Cross-group comparisons

Preliminary evidence for different patterns of responsiveness to training
Where is the core deficit? Does it predict response to intervention?

- Children with SLI, using AWMA and Working Memory Diagnostic Instrument (WMDI)
Children with Specific Language Impairments

- 14 SLI profile (expressive and receptive language difficulties)
- 15 age, gender and NVIQ matches

![Bar chart showing WM scores before training for Verbal STM, Visuo-spatial STM, Verbal WM, and Visuo-spatial WM. The chart compares SLI and Comparison groups.](chart.png)
Children with Specific Language Impairments

WMDI profile before training
## Training-related changes in WM scores

<table>
<thead>
<tr>
<th>WM</th>
<th>Measure</th>
<th>SLI</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal STM</td>
<td>Digit Recall</td>
<td>105.31</td>
<td>101.48</td>
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<td></td>
<td>Word Recall</td>
<td>91.07</td>
<td>103.9</td>
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<td></td>
<td>Composite</td>
<td>98.71</td>
<td>100.49</td>
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<tr>
<td>VS STM</td>
<td>Dot Matrix</td>
<td>106.06</td>
<td>109.87</td>
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<td></td>
<td>Block Recall</td>
<td>103.91</td>
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<td>Composite</td>
<td>104.98</td>
<td>106.20</td>
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<tr>
<td>Verbal WM</td>
<td>Listening Recall</td>
<td>97.06</td>
<td>104.79</td>
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<tr>
<td></td>
<td>Backward Digit Recall</td>
<td>95.84</td>
<td>108.38</td>
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<tr>
<td></td>
<td>Composite</td>
<td>95.47</td>
<td>105.54</td>
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<tr>
<td>VS WM</td>
<td>Mr X</td>
<td>98.31</td>
<td>102.91</td>
</tr>
<tr>
<td></td>
<td>Spatial Recall</td>
<td>101.68</td>
<td>108.46</td>
</tr>
<tr>
<td></td>
<td>Composite</td>
<td>100.00</td>
<td>105.69</td>
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</tbody>
</table>

Preliminary evidence that cognitive difficulty outside WM may limit response to WM intervention
Summary

• Working memory supports learning

• Deficits are common in many developmental disorders (and occur independently)

• WM impairment might not be a core deficit
  - could be a secondary consequence of a difficulty elsewhere

• Cause of WM difficulty limits response to intervention
  • WM training generalised improvements in ADHD & low WM groups
  • BUT constrains response in verbal aspects of WM in children with language problems

• Inform choice about intervention