Working Memory Workshop

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Aims of workshop

For participants to:
- understand working memory systems relevant to language processing
- understand the implications of poor working memory for assessment /intervention
- have hands-on experience testing working memory
- understand the evidence base around working memory training programmes
- consider application to clients
Cognitive training programmes are now multi-million dollar businesses. It is important for SLTs to understand what WM is and how it interfaces with language so we can:

- Inform your recommendations for working memory assessment / intervention
- Give advice to parents of children who have limited WM spans.
How do you learn language without a good memory?

Much research done on the interaction of memory systems and language processing. Poor working memory is a current causal theory of SLI (Bishop, 2006). Poor working memory is commonly associated with specific learning disabilities e.g. dyslexia (Dawe, Leitao, Claessen & Nayton, 2015).

**Memory and Language**

- Up to 20 seconds (depending)
- Limited capacity – 4 chunks
- Storage, rehearsal and retrieval
- Decay – mitigated by rehearsal
- Measured by simple span tasks
- Examples – phone numbers, exact sentence someone said, how to spell a new word, how to say a new word

_Baddeley (2000)_

**Short term memory**

- Unlimited capacity
- Gateway to LTM is STM
- Storage and retrieval
- Cue dependent – can access information given right cues
- Can be divided into two areas
  - Declarative e.g. vocabulary, faces
  - Procedural e.g. how to ride a bike, grammatical understanding of a sentence, keyboard skills, swimming

_Baddeley (2000)_
Working memory

• Involves processing of information stored in long term and short term memory

NB. we use ‘short term memory’ for storage alone and ‘working memory’ for storage and processing.

• Closely linked to language processing are:
  – phonological short term memory
  – verbal working memory

Baddeley (2000)

Baddeley’s model of working memory (2000)

• Proposed to be a specialised memory system which sets up long term representations of phonological forms necessary for learning new vocabulary.
• Capacity of phonological loop
• Assessed through repeating increasingly long non-words e.g. “strimperdiction”
• Many studies have shown non-word repetition is an extremely sensitive test of past and current Language impairment (e.g. Bishop, North & Donlan, 1996)
• Try out non-word repetition test

Phonological short term memory
Research on PSTM and language

- WM span increases with development (Gathercole & Hitch, 1993)
- PSTM tends to be poor in children with SLI even relative to language matched peers (Gathercole and Baddeley, 1990).
- Higher PSTM associated with higher vocabulary and syntax in preschool years (Newbury et al., 2015 / in press; Chiat & Roy, 2008)
- PSTM associated with better phonological awareness and acquisition of decoding skills (Gillam & van Kleeck, 1996)
- Specific acquired PSTM deficits associated with difficulties learning foreign vocabulary and comprehension of complex syntax (Baddeley, Papagno & Vallar, 1988)

Research on PSTM and language

- Strong evidence of PSTM involvement in learning novel phonological forms.
  - The better you can recall a novel word form, the fewer repetitions of it you need before a strong representation is laid down in LTM and it has become part of your vocabulary.
- A slow start to vocabulary acquisition is common pattern seen in children with SLI.
- Children with resolved early vocabulary delays usually have a shorter PSTM span even once they have caught up with language (Bishop North, Donlan 1996).
- There is also some evidence to suggest PSTM is involved in the acquisition of morpho-syntax as well, a key deficit in SLI (Chiat and Roy, 2008).
Verbal working memory

- Proposed to involve both **storage** and **processing** of verbal information
- Assessed in listening span task e.g. child hears “pumpkins are purple (true / false); balls are round (true / false)” and then recalls the last word in both statements (Alloway, 2012; Tompkins et al., 1994)
- Children with SLI have consistently shorter **listening spans** for sentences than TD children. Most have shorter spans than language matched younger TD children. (Archibald & Gathercole, 2006)
- Try out the working memory measure

Verbal working memory

- VWM and language skills show a **strong association** in children with SLI and TD children.
- Evidence of VWM involvement in **sentence comprehension**, **inferences**, **metaphors**, **story generation**, and **discourse skills**. The conscious processing of complex new language for the purposes of comprehension.
- Central executive is thought to be **weaker** in children with SLI.
- **Mixed evidence** of executive Function deficits in children with SLI – more common in those with a severe disorder.
- VSWM shows some weaknesses in children with SLI due to **involvement of the Central Executive but not the Visuospatial Sketchpad**.

What impact could a low VWM span have on language?

- Poorer comprehension of **complex grammar / discourse**
- Fewer **semantic links** between words
- Difficulty with **inferences**
- More **effortful processing** even of simple sentences e.g. SVO
- Slower academic learning
- More **difficulty correcting errors**
- More **difficulty processing multiple streams** of input

(Zaretsky, 2004; Montgomery & Evans, 2009; Baddeley, 2010)
Can we separate WM and language for assessment purposes?

- If you are assessing verbal WM – by definition, no.
  - Can reduce semantic / syntactic processing demands so the linguistic demands are well within the ability of the child. The WM load increases as task progresses.

- If you are assessing PSTM – by definition, no.
  - You can reduce wordlikeness. Will always be a phonological task. Can keep the phonological demands within the ability of the child, so mainly the memory load increases as words get longer.

- Can more easily assess visual spatial working memory systems separately from language – but people may use language strategies

Investigation: Can working memory and language scores stand alone?

- Archibald & Joanisse (2009) tested 400 school-aged children on WM / Language / IQ tests
- They identified 6 subgroups of children
  - Language impairment only
  - Working memory impairment only
  - Language and working memory impairment
  - WM impairment in either verbal or visual spatial
  - LI and WM impairment in either verbal or visual spatial
  - No language / WM impairments

Implications from the study

- YES the subgroups tell us they dissociate
- It also casts doubt that poor WM is a causal factor in Language Impairment
- The correlations between WM and language are strong but are not perfect
  - Poor working memory alone is insufficient to cause a language impairment. Also it is not necessary as children can have a LI without a WM impairment. (Bishop, 2006)
- There must be other factors which affect language and working memory abilities
  - E.g. Processing speed, procedural memory, auditory processing
Assessing Working Memory

• WM tests which SLTs with a bachelor’s level qualification can use:
  – CELF-4 (Semel, Wiig & Secord, 2006) subtests – Memory Composite includes span tasks
  – Automated Working Memory Assessment II (Alloway, 2012)
  – Working Memory Rating Scale (Alloway, Gathercole & Kirkwood, 2008)

Postgraduate qualification:
  – Working Memory Test Battery for Children (Gathercole & Pickering, 2001)

Example from Concepts and Directions (CELF4)

• Point to the house in the top row

Example from Concepts and Directions (CELF4)

• PSTM / VWM
• Linguistic system
  – Semantics
  – Syntax
• Visual spatial
• Episodic buffer
• Pointing

• Relies more on verbal memory and linguistic understanding
Recalling sentences (CELF4)

• Repeat after me:
  – “The van was preceded by the ambulance”
  – No visual stimuli
  – No repetitions allowed
  – No processing per se required, just a repetition, however studies show that people do process the meaning automatically and if they can’t recall the sequence of words perfectly, recreate a new sentence with similar meaning
  – PSTM and linguistic system
  – SR – measures primarily linguistic system

Comments on sentence repetition

• Either delayed or immediate repetition
• Proposed as a clinical marker of SLI
• Klem et al., (2015) reported results of a longitudinal study looking at interrelationships between language, WM, and sentence repetition.
  – Concluded that SR is best seen as a measure of underlying language ability rather than memory
  – Useful for lang ax as it draws on a wide range of language processing skills

Implications for assessment

• Consider the WM demands of the tasks given
• Sentence repetition taps both STM and core language skills in LTM
• Consider the visual support available in subtests as this reduces the load on WM
• Consider how familiar the vocabulary is, as this reduced the load on WM
• However be cautious in simple interpretations
• CELF-5 has WM subtest – refer for further cognitive testing if difficulties noted. Don’t interpret it.

Take home point:
Don’t try to separate WM and language entirely – they work together as an integrated system. However some students have a more marked difficulty with one or the other.
Case 1 -
• WD age 8 years 1 month (male)
• TONI score 109

<table>
<thead>
<tr>
<th>Language Test</th>
<th>Core Language Scale</th>
<th>Concepts and Directions</th>
<th>Word Structure</th>
<th>Recalling Sentences</th>
<th>Formulated Sentences</th>
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<tbody>
<tr>
<td>Standard score</td>
<td>81</td>
<td>10</td>
<td>4</td>
<td>7</td>
<td>6</td>
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</table>

Standard scores have a mean of 100 (10) and standard deviation of 15 (1.5)

Case 2 -
• HB 8 years old, female
• TONI score 87

<table>
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<tr>
<th>Language Test</th>
<th>Core Language Scale</th>
<th>Concepts and Directions</th>
<th>Word Structure</th>
<th>Recalling Sentences</th>
<th>Formulated Sentences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard score</td>
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<td>4</td>
<td>5</td>
<td>4</td>
<td>6</td>
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</tbody>
</table>

Investigation: What do mild LI / mild – mod WM difficulties look like in class?

• Archibald, Joanisse & Edmunds (2011)
  – Children with SLI / SWMI / both presented similarly in class
  – Teachers perceived their behaviour mainly as difficulties with attention, language and behaviour
  – Children with WM difficulty were reported to have difficulty with language (e.g. needing more explanations) children with language difficulties were reported to have difficulty with memory
  – Having difficulties in both did not double their problems in class – mainly presented as an LI
Commonly reported behaviours of children with WM / LI

- inattention
- failure to monitor the quality of work
- lack of creativity in problem solving
- speaking over others
- needing instructions repeated
- incorrect / inadequate answer to question
- careless mistakes
- does not wait for turn
- miscommunications...

Application to your caseload

- Consider a child on your caseload whom you know/ suspect has working memory difficulties:
  - What assessments have been done to confirm this?
  - Would confirmation of WM or other cognitive difficulties through assessment by yourself or a psychologist be helpful?
  - What intervention supports can be / have been offered to this child to either compensate or improve his/her WM limitations?

Implications for WM intervention

- Children often asked to store a considerable amount of information and then act on it in class
- Task performance = capacity limits, knowledge representation and strategy use
- How are tasks communicated, how is information delivered?
- What increases WM demands? – new concepts, new vocabulary, less visual support, complex sentences, limited time to process
Implications for WM intervention Cont.

Example tasks:
Following instructions; writing tasks especially when new for the student; paragraph comprehension; reading comprehension; mental calculations for math e.g. word problems.

General rule of thumb – one new thing at a time.

• if vocab is new, keep syntax simple.
• if concepts are new, use familiar vocabulary to explain it.
• Complex sentences have the best chance of being understood once the vocabulary and concepts are familiar.

WM Intervention options

• Reduce the impairment
  – Working memory training (commercial programmes)
  – Language intervention which incorporates increasing demands on working memory in the task
• Compensation
  – Strategy use to reduce the impact of the working memory difficulty
  – Information given to child / family / teachers

Key WM compensatory strategies – students’ role

• Improve metacognition and use of strategies
  – Teach children to reflect on the task and what they can do to help themselves
  – Suitable for older children e.g. 9+
  – Students with LLD less likely to use strategies than TD children even when taught
• Examples
  – Rehearsal strategies – chunk, repeat
  – Task analysis - steps needed
  – Visualise – following instructions, or overloading for some
  – Study / organisation skills – make a study plan
Key WM compensatory strategies – teacher or whānau role

• Repetition
• Chunking – pause and summarise
• Biggest hurdle is starting the task
• Ask student to repeat to you what you said
• Slow down rate of speech
• Do one part of task then come back

Key WM compensatory strategies – teacher or whānau role

• In group discussions, ask child with poor WM to contribute 1st rather than 3rd or 4th
• Present information visually
  – Graphs, charts, schedules, written instructions, diagrams,
• Pre-teach information
• Increase automaticity of skills

Working memory training

• Recent surge in working memory / cognitive training programmes available commercially online e.g. CogMed/ Jungle Memory / Lumosity
• Concept of neuroplasticity
• Part of the search to remediate cognitive disorders
• Huge public interest and appeal
• Multi-million dollar industry
Luminosity quick look

A closer look at CogMed

- [https://www.youtube.com/watch?v=vUYWF1x d3cl](https://www.youtube.com/watch?v=vUYWF1x d3cl)

Excerpt of research summary from CogMed website:

- States the following claims are supported by evidence:
  - CM results in sustained improvements (2-12 mo) in WM from children – adults (30 studies)
    - NB most outcome measures similar to training tasks
    - NB improvements in visual more common than verbal memory
  - Learning outcomes in reading / math for some but not all students
    - NB WM only one factor in academic success; might be cumulated benefits over time
- Acknowledges that WM is easy to measure in laboratory situations but not in everyday life – this limits the research base

Soderqvist & Nutley (2016)
The only study published so far on WM training with children with LI
- Used Cogmed
- Compared 8-11 yr old TD children (n=15) / children with LI (n=12)
- Both groups showed minimal gains in verbal memory except better NWR at 5 syllable level in LI group
- Both groups showed significant gains in VSSTM
- Those with lower verbal IQ initially made more gains in verbal memory and VSSTM
- Concluded that WM training may be useful for some children with LI

Holmes et al. (2015)

Independent systematic / meta-analysis reviews

- None of these reviews below found the evidence presented by Cogmed to be convincing e.g.
  - The effect size confidence intervals accumulated across the highest level studies crossed zero
  - They queried the value of training the test
  - Subjective bias in teacher / parent questionnaires

- They concluded the evidence so far is unconvincing that Cogmed improves WM or attention or that it transfers to academic outcomes.
- WM training is a work in progress
  - Hulme & Melby-Lervag (2012)
  - Shipsted, Randall and Engle (2012)
  - Redick et al. (2015)

Our thoughts on CogMed

- Cost around $1500 for 5 week training
- Can be done alongside mainstream schooling
- Training tasks are not very similar to functional everyday activities
- Likely to result in child getting better at tasks trained
- May have a positive psychological effect e.g. child believes they can learn, attend better, succeed?
- Money probably better invested in individual tutoring in reading / maths / language i.e. functional practice at meaningful tasks at the child’s level
- Fundamentally this is a parent decision
Summary/Recap

- Revision of working memory
- WM and language work together as an integrated system.
- Revision of what language assessments tell us about working memory
- Compensatory and intervention ideas discussed for working memory
  - A language intervention approach will target WM and language
  - A working memory approach targets the tasks worked on

References


References


