The impact of working memory and language skills on academic achievement

Facilitators

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Introduction

- Cross-disciplinary advantage in addressing and problem-solving common clinical presentations
- If language concerns are ruled out, what’s the next step?
- Maximising the use of the resources and tools

Teacher report: “Child not progressing”

- Jack is in Kindy (Prep)
- Aged 6 years and 3 months
- Jack is making slow progress
- He has particular difficulty with following directions
- He has poor communication skills

Jack’s not progressing...

- what does this mean?
- how do you know?
- what do you do?
Where do you start?

- Teacher / parent report
- Classroom observation using the CELF-4 Observational Rating Scale, completed by the:
  - Teacher
  - Clinician, and
  - Parent
- Conduct a formal language assessment

Speech-language assessment is a complex process.

Assessing, describing, and interpreting an individual’s communication ability requires the integration of a variety of information gathered in the evaluation process.

(ASHA, 2004)

Jack obtained a Core Language Score of 84
- Confidence interval of 79–89
- Percentile rank of 14
- The score and the confidence interval are in the borderline range indicating mild language impairment
Jack's **Receptive Language index score is 90**
- Confidence interval of 82–98; percentile rank of 25
- This is within the **average range**

Jack's **Expressive Language index score is 87**
- Confidence interval of 81–93
- A percentile rank of 19
- Placing Jack's Expressive Language index score in the **borderline to average range**

Jack's **Language Content index score of 94**
- Confidence interval of 88–100
- Percentile rank of 34 indicating **average** performance.
- The **Language Structure index** extends from the **borderline range to the average range** of performance.

**What do you mean by “borderline”?**

The CELF test development team and the speechies at Pearson Clinical Assessment interpret “being bordering” to mean a student does not clearly have a significant moderate to severe language disorder, but s/he is performing right at the edge (the borderline scores) that can either be interpreted as “low-average” or “mild disorder” especially when taking the confidence bands into account.

The authors talk about “borderline” skills to highlight for speechies that scoring right above the schools or funding body's criterion doesn't mean the child is performing fine but that s/he is at risk of mastering classroom level curriculum because language skills are low, but the scores on the CELF do not necessarily indicate the presence of a language disorder.

Identifying borderline scores highlights the need of the speechie to obtain additional information from the teacher and from observations of the student in the classroom as well as with peers before identifying the student as having a disorder.

Further assessment is needed to determine what underlying clinical behaviours may be affecting language performance.
The following Level 3 subtests were administered:
- Word Associations
- Phonological Awareness
- Rapid Automatic Naming
- Working Memory subtests

Jack met the Word Associations criterion with a score of 19.

He did not meet criterion on the Phonological Awareness subtest.

Jack was unable to complete the Rapid Automatic Naming subtest, despite repeated attempts.

Jack’s Working Memory index score is 77 with a percentile rank of 6, indicating performance in the low range.
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That’s the theory, but you have to do the work....

I’m happy to pay you and you fix the problem.

This will be hard work. There’s no magic easy solution. We’ll need to work together, and you’ll need to do exercises every day – are you ready for that?

Interconnected Systems Supporting Learning

Performance-based factors
- e.g. Holding on to new information, processing arbitrary symbols.
- Language delivered via rapidly vanishing form
- Working memory and executive function skills: focus, organisation, problem-solving skills

Knowledge base (LTM)
- e.g. phonics, vocabulary, number concepts
- Learned over multiple trials.
- Fairly automatic once learned.
- Automatic responses place lower demands on working memory

What is working memory?

A system for temporary storage and manipulation of information, necessary for wide range of cognitive tasks

The ability to keep information active in your mind for a short period of time (seconds) keeping it available for further processing

Alan Baddeley’s Working Memory Metaphor

Central Executive
- Phonological Loop
- Episodic Buffer
- Visual-Spatial Sketch Pad

Language Episodic Memory Visual Semantics
Example Working Memory Characteristics

**Verbal WM**
- Remembering instruction/content of instruction
- Remembering what to say when called upon
- Paraphrasing spoken information
- Comprehending syntactically complex sentences

**Verbal STM**
- Remembering/repeating multistep oral instructions
- Counting
- Blending phonemes into words when reading
- Phonetic decoding of text/phonetic recoding (spelling)
- Learning new vocabulary

**Visual-Spatial WM**
- Following signs (e.g. +, -, x) during arithmetic calculation
- Keep place on page when reading
- Mental manipulation of images
- Reverse sequence of objects
- Transform information

**Visual-Spatial STM**
- Remembering objects
- Remembering colours
- Remembering location
- Remembering direction

**Working Memory (WM) Performance: Dependent on Many Variables**

- **WM capacity** – affected by deficit, disease, genetics, age… but also fatigue, medication, mood.

- **WM load** – determined by the difficulty of a task as well as level of distraction from relevant and irrelevant stimuli. The more difficult the task, and the more stimuli attended to, the more demand on the WM.

\[ \text{WM capacity} + \text{WM load} = \text{WM performance} \]

**Holmes, Gathercole Dunning 2010**

Poor Working Memory: Impact and Interventions

- Working Memory impairments are associated with a wide range of developmental disorders of learning, including ADHD, Dyscalculia, Dyslexia, SLI

<table>
<thead>
<tr>
<th>Verbal STM</th>
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Children with poor working memory function are at very high risk of educational underachievement
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Getting the most out of the CELF-4

Rapid Automatic Naming

Diagnostic Purpose

to evaluate speed, accuracy and fluency of automatic naming

1. Phonological Awareness
   - evaluates sound knowledge and ability to manipulate sounds in words

2. Number Repetition
   - to evaluate working memory and the ability to repeat random digit sequences with both numbers forward and numbers backwards

3. Familiar sequences
   - to evaluate the ability to manipulate and sequence auditory/verbal information as quickly as possible

4. Word Associations
   - to evaluate the ability to name members of semantic classes/classifications rapidly and efficiently (word retrieval skills)
Getting the most out of the CELF-4

- Cognitive skills that have been associated with executive functioning:
  - cognitive flexibility
  - planning
  - initiation of goal-directed behaviour
  - conceptual reasoning
  - inhibition of impulsive responses
  - Ability to create and maintain a cognitive set (rule-governed behaviour), and
  - self-monitoring of goal-directed behaviour


How does this apply to language and CELF-4 performance?

- Problems with cognitive flexibility may result in difficulties developing more than a single response to a test item
  - Sentence Assembly
- Impulsive responses that may result in incorrect or inappropriate responses
  - inappropriate, incomplete, or incorrect verbal expressions on Formulated Sentences
- Difficulties with maintaining rule-based behaviour (cognitive set) might result in incorrect or repetitive response on word production tasks
  - Word Associations & Rapid Automatic Naming

Jack’s CELF-4 Summary and Recommendations

- Jack’s CELF–4 scores range from borderline to average.
- He does not meet criterion on the phonological awareness assessment, and further testing is indicated.
- Jack’s Working Memory index score indicates a need for further testing in memory skills.
Case Study 2

Tyler is in high school and is new to your school

1. He has moved interstate
2. His academic record shows that he may present with some learning difficulties
3. He has never had speech-language intervention, nor has he been assessed in this area; some reports indicate that there may be a delay in this area, but it's not very clear
4. You administer the CELF-4 Screening Test

Implications of Performance

If the student’s Total Score is equal to or greater than the Criterion Score for his/her age, circle the + for ‘At or Above Criterion’

This score indicates that the student probably does not need further language testing

Further testing may include cognitive and achievement testing such as the WISC-V or WIAT-III

Psychological Processes associated with academic learning (Dehn 2012)

10-15% of all students have working memory deficits causing them to perform below average in many areas of learning

Working memory is crucial for areas such as maths, reading comprehension, complex problem solving, and test taking
Signs of working memory constraints

- Is easily distracted when doing something not highly interesting
- Has trouble waiting his/her turn – will often interrupt you or put their hand up to ask a question and then forget what to say
- Struggles with reading comprehension, doing maths calculations in their head
- Struggles with getting started and completing a task. Watches and depends on neighbour to remind them of the current task
  - Difficulty organising something with multiple steps... frequently stops, frequently loses their place
  - Often seems restless and on the go
  - Loses belongings frequently
  - Makes slow progress despite working hard

Gathercole & Alloway 2008

Children with poor working memory make characteristic errors in their classroom work:
- failing to keep track of their place in demanding and complex activities
- Mistakes in writing and counting
- Failing to self-correct

"...Over time these frequent missed learning opportunities amount to slow educational progress and poor academic attainment"

Clinical Observations of WM Deficits

- Poor memory of contextual information so unable to use context clues to predict words or assist in word attack (decoding)
  - "Quench your thirst" by drinking a glass of water.
- Segmenting and Resynthesizing Phonemes in a String
  - s-t-r-i-n-g becomes 'stirring' or 'sing'
- Foreshortening after successful syllabification
  - Re/member becomes rem/ber

Clinical Observations of WM Deficits (con’t)

- Number of instructions/steps when syllabifying
  1. underline vowels
  2. Cross silent letters
  3. Find prefix and mark as first syllable
  4. Find suffix and borrow consonant if it is a vowel suffix so as to form final syllable
  5. Difficulty holding dual attack information: Syllables and Morphemes

Prefix Root Suffix

Construction Safely
Specific Literacy Strategies Requiring WM Input

- Blending and Segmenting words and non words from listening
  - i. What word do these sounds make? ...sl/tep/t (slipped)
  - ii. Sound out ‘crept’ one sound at a time...c/r/e/p/t

- Phoneme Reversal
  - i. What real word do you get when you say zmitmus backwards? (sometimes)

- Elision
  - i. Say fixed but don’t say /k/ – “fist”

How does Cogmed fit into an intervention program?

1. Structure the environment
2. Teach strategies for coping
3. Intensive training on WM tasks to strengthen working memory capacity

POOR WORKING MEMORY: IMPACT AND INTERVENTIONS

Working memory strategies for the teacher/clinician/coach

- Evaluate working memory demands of daily activities
- Reduce the working memory load – simplify, chunking, structure differently, slow the pace, break big goals into smaller ones
- Reduce processing demands – fewer bits to remember, build redundancy (visual cue = verbal cue)
- Increase repetition
- Encourage memory aids – props they can touch hold, represent information with
- Build routines and familiarity – reduce the amount of new information: what they already know

Strategies to cope

For individuals:
- It’s ok to ask for help, e.g. repetition, simpler instructions
- Pair up with a friend and share the load
- Write things down, take a photo
- Slow it down – pace is important
- Limit distractions – e.g. social media, screen time
- Visualise – draw a picture
- Take a deep breath when you feel overwhelmed
What works?

The characteristics that make successful strategies work include:
- meaningfulness,
- organisation,
- association,
- visualisation and
- interest

Why do they work? The more you already are familiar with something, the less you have to hold in memory

⇒ familiar routines, careful structuring of content

Put information in the world, not in their heads

Neuroplasticity makes working memory training possible

Principles of Neuroplasticity:

- **Use it** – Train! Knowing is not enough
- **Improve it** – Challenge is necessary for change
- **Specificity** – Neurons that fire together wire together
- **Repetition** – Need to practice
- **Intensity** – Need to work hard
- **Salience** – Needs to be meaningful, personalised


Cogmed Working Memory Training

An evidence-based intervention for working memory

**Research-based exercises** - Cogmed emerged out of research on the plasticity of working memory and backed up by peer reviewed, published, and fully independent studies

⇒ High level of support - Always provided through a professional accredited coach

How does Cogmed meet the criteria for ideal cognitive training?

<table>
<thead>
<tr>
<th>Principles</th>
<th>Cogmed</th>
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<tbody>
<tr>
<td>Training</td>
<td>Engaging exercises</td>
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<tr>
<td>Challenge is necessary for change</td>
<td>Adaptive algorithm</td>
</tr>
<tr>
<td>Specificity</td>
<td>Only working memory exercises</td>
</tr>
<tr>
<td>Repetition – Need to practice</td>
<td>15-20 trials for each area, overlapping areas of WM</td>
</tr>
<tr>
<td>Intensity</td>
<td>Structured protocol, 25-30 sessions of 20, 35 or 50 minutes, over 5-10 weeks</td>
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<tr>
<td>Salience</td>
<td>Don’t start until motivation and goals established</td>
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<tr>
<td>Feedback</td>
<td>Professional support, weekly review built into training protocol</td>
</tr>
</tbody>
</table>
Three products for Cogmed training

- Cogmed JM: Preschoolers
- Cogmed RM: School-age
- Cogmed QM: Adults

All the products share the same underlying design – the only difference is in the user interface.

Cogmed RM Demo

Download the free Cogmed App
On an iPad and Android
Or browse to http://mycogmed.com
"See how it works"

Working memory training acts on underlying levels

<table>
<thead>
<tr>
<th>Skill/behaviour</th>
<th>Reading comprehension</th>
<th>Maths skills</th>
<th>Language development</th>
<th>On-task behaviour</th>
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</thead>
<tbody>
<tr>
<td>Affects</td>
<td>Rate of learning</td>
<td>Manipulating information</td>
<td>Remembering directions</td>
<td>Attention/Concentration</td>
</tr>
<tr>
<td>Executive functions</td>
<td>Working memory</td>
<td>Planning</td>
<td>Initiate</td>
<td>Task monitoring</td>
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</table>

Time Taken (Initial Review to Completion 8.2, 8.5)
Gain in Reading Age (20, 25 months)

Change in Reading Rate (2.6, 3.2 months / month)

How do we know working memory can be trained?

The same program used in real life are used in the research.
The research uses controlled studies – eliminating placebo effects.
The research is done at leading universities.
...by a broad range of independent researchers.

80+ research studies
See www.cogmed.com.au/research

Effects of working memory training on reading in children with special needs

Karin I. E. Dahlin
Springer Science+Business Media B.V. 2010

Abstract: This study examines the relationship between working memory and reading achievement in 57 Swedish primary-school children with special needs. [Reading Difficulties]

Working memory measures were found to be related with children’s word reading and reading comprehension. The results show that working memory can be seen as a crucial factor in the reading development of literacy among children with special needs, and that interventions to improve working memory may help children becoming more proficient in reading comprehension.
The following are recommended to help Jack with his memory, attention, and communication difficulties:

**Memory**
(In addition to Cogmed Intervention)
- Pairing spoken directions with visual prompts (e.g. when asking Jack to get a book off the shelf, point to the shelf where the books are kept, signal Jack to be quiet by placing your index finger over your mouth)
- Speak to Jack in short, simple sentences.
- Ask Jack to repeat back what you said to verify that he heard your message.
- Limit the number of directions you give Jack.

**Attention**
- Give Jack a consistent visual (e.g., hold up hand) or tactile (e.g., put your hand on Jack’s shoulder) to signal that you want his attention.
- Provide Jack with structured tasks that have clear start points and end points. For example, cue Jack to “start on page one and stop on page three.” Attach a sticky note on page three to remind Jack when to stop reading.
- Limit Jack to two options when asking him to make choices. Presenting Jack with too many choices will likely overwhelm him.

**Jack’s Progress Summary**
- Following the Cogmed Intervention, Jack’s received 8-weeks of phonological awareness therapy, and general core vocabulary intervention.
- His receptive and expressive language skills are yet to be formally assessed, however, his teacher reports that he is coping well with his school work, including his reading.
- His spelling requires ongoing monitoring, as he sometimes struggles to apply new rules to his written work.
- Working Memory maintenance includes Cogmed extension and new challenges.
- His parents and teacher report that “he is a happy, healthy, resilient little boy who is thriving and loving school!”

**Summary**
- Get the most out of your tools
- Look at the bigger picture
- Learn more

www.cogmed.com.au
www.pearsonclinical.com.au
For more information about the CELF-5, simply visit: http://bit.ly/20UnDrs. The CELF-5 will be available in both print and digital (iPad) versions.