In this webinar we look at the role played by working memory in development of literacy skills and will include examples of successful literacy intervention programs.

Agenda

- What is Working memory and how does it affect language, literacy and learning?
- Where are we likely to find working memory problems?
- What strategies can you use to manage working memory constraints and improve literacy outcomes?
- What is Cogmed? How is it offered in Australia and NZ? How might it fit into a literacy intervention program?
- What evidence is there that working memory training might improve language and literacy skills?

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.
"Body', 'soul', and 'spirit' may designate phenomenal domains which can be detached as themes for definite investigations; within certain limits their ontological indefiniteness may not be important.

When, however, we come to the question of man's Being, this is not something we can simply compute by adding together those kinds of Being which body, soul, and spirit respectively possess—kinds of being whose nature has not as yet been determined.

And even if we should attempt such an ontological procedure, some idea of the Being of the whole must be presupposed.”

— Martin Heidegger, Being and Time

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**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.

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

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**Alan Baddeley’s Working Memory Metaphor**

- **Central Executive**
- **Phonological Loop**
- **Episodic Buffer**
- **Visuo-Spatial Sketch Pad**

**Phonological loop up close**

- Represented by phonological store which can only hold information for a few seconds before it fades
- Rehearsal process (inner voice) rehearse information in order to refresh the memory trace
- The loop has a limited capacity so if articulatory speed is slow the info is lost before it is rehearsed
The role of **language** in working memory

- ‘Working memory allows us to integrate current perceptual information with stored knowledge, and to consciously manipulate the information (**think** about it, **talk** about it and **rehearse** it) well enough to ensure its storage in long-term memory’ Wolfe 2001

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**Route 1: Working Memory & Learning**

- Actively monitors & manipulates information in current focus of attention
- New information
- Needed information
- Transformed / derived information

- Early in the learning process
- Supports development of the knowledge base

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**Working Memory and Language**

- **WM** may have specific impact on language learning
- Language is delivered in a rapid code
- Language is largely delivered via acoustic waveforms
  - Vanish rapidly
  - Time-dependent

  Bishop, 1992; Kail, 1994
Working Memory and Literacy

Reading dependent on decoding
Arbitrary connection between speech sounds and letters

Effortful decoding places high demands on WM
Retention for comprehension

Working Memory and Numeracy

Math relies on connections between numbers and symbols
Numerical symbols are arbitrary

Operations require retention of intermediate products

Route 2: Language & Learning

Stores of knowledge based on human verbal code for communication
Learned over multiple trials
Fairly automatic once learned
  *automatic responses place lower demands on working memory

Supports learning of related concepts (networks of knowledge)
Increasing importance over learning process

Language Scaffolds Language Learning

Verbal skills support language learning
Familiar word types easier to remember
  – E.g., daevacheenoitag vs. trumpetine

New grammatical forms that fit existing rules
  – E.g., wuffed; tweet/twat

Sentence comprehension with known vocabulary/context
Language and Literacy

Word recognition
Word prediction
Sentence comprehension forms units of understanding
Familiar context supports retention of read material

Language and Numeracy

Verbal codes for numerical concepts
One; two; three....

Word problems
Tap existing language base

Interconnected Systems Supporting Learning

Performance-based factors

Knowledge base (LTM)

e.g. Holding on to new information, processing arbitrary symbols, Language delivered via rapidly vanishing form

Performance-based factors

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

Working memory underlies language development skills

Skill/behaviour
Reading comprehension
Maths skills
Language development
On-task behaviour

Affects
Rate of learning
Manipulating information
Remembering directions
Attention/Concentration

Executive functions
Working memory
Planning
Initiate
Task monitoring
Organise
Psychological Processes associated with academic learning (Dehn 2012)

What is involved in learning to read?
Five Pillars

- Comprehension – Putting all the pieces together.
- Vocabulary – Can’t understand what they’re reading without knowing what most of the words mean.
- Fluency – The ability to read accurately, quickly and expressively
- Phonemic Awareness – Understanding the structure of language. Word attack skills, decoding skills
- Phonological awareness – Turning Sounds into Letters. Phonics is the crucial link between what kids hear and how they read and write

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
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Signs of working memory constraints

✓ Is easily distracted when doing something not highly interesting
✓ Has trouble waiting his/her turn
✓ Struggles with reading comprehension
✓ Struggles doing math calculations in his/her head
✓ Struggles with getting started and completing a task
  ✓ Difficulties when planning and organising something with multiple steps
  ✓ Makes poor progress despite working hard

Holmes, Gathercole Dunning 2010
Poor Working Memory: Impact and Interventions

Working Memory impairments are associated with a wide range of developmental disorders of learning

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<tr>
<th>125</th>
<th>120</th>
<th>115</th>
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<td>Verbal STM</td>
<td>Visual-spatial STM</td>
<td>Verbal WM</td>
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Dyslexia

• Difficulty in processing and remembering verbal information
• de Jong (2006): Dyslexia involves deficits in both the phonological loop and central executive functioning.
• Brain imaging studies have found dyslexics all showed the same brain deficits – large overlap with same areas involved for working memory
• Working memory also affects:
  • acquisition of phonics
  • spelling
  • reading comprehension

Areas activated on reading - Dehaene 2009
Alloway et al., 2009

- First study in which participants selected on basis of WM rather than learning difficulties, developmental disorders or genetic syndromes
- 3,189 5-11 year olds, 308 identified with low WM using AWMA – 10%
  - High risk of making poor academic progress
  - Highly distinctive profile of inattentive behaviour and forgetting which disrupts classroom functioning
  - Older group performed significantly more poorly than younger group on learning measures

- Distractibility
- Forgetting
- Failure to remember instructions
- Failure to complete tasks
- Careless mistakes
- Difficulty solving problems
- Not hyperactive/impulsive

Evidence that, even when general ability is accounted for, working memory skills predict reading and math scores

Working memory is key for academic and occupational performance

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

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”
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What can you do to manage working memory constraints?

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

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, tell them what you’re going to tell them
- Reduce processing demands – fewer bits to remember, build redundancy (visual cue = verbal cue), build in thinking time when asking questions
- Increase repetition – particularly important in vocab learning
- Encourage memory aids – summaries, props they can touch hold, represent information with, colour coding sounds and words
- Build routines and familiarity – reduce the amount of new information: what they already know

Working memory strategies for the teacher/clinician/coach

- Evaluate working memory demands
- Reduce the working memory load
- Encourage memory aids
- Increase repetition
- Build routines and familiarity
- Reduce processing demands
Classroom oral language checklist

<table>
<thead>
<tr>
<th>Issue</th>
<th>Strategy examples</th>
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<tbody>
<tr>
<td>Balance of oral and other forms of communication</td>
<td>- Use a written or pictorial summary of the oral presentation</td>
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<tr>
<td></td>
<td>- Provide summary notes to students</td>
</tr>
<tr>
<td></td>
<td>- Use visual aids and demonstrations wherever possible</td>
</tr>
<tr>
<td>Content: complexity checks</td>
<td>- Vocabulary, sentence length, too many instructions at once, explicit vs. implicit language etc.</td>
</tr>
<tr>
<td></td>
<td>- Beware of students’ literal interpretations!</td>
</tr>
<tr>
<td>Organisation and sequence</td>
<td>- Make a plan for a well-sequenced introduction of ideas.</td>
</tr>
<tr>
<td></td>
<td>- Explain links, how ideas relate to each other</td>
</tr>
<tr>
<td></td>
<td>- Use visual aids e.g. concept maps, time lines...</td>
</tr>
<tr>
<td>Chunking information</td>
<td>- Small, meaningful units</td>
</tr>
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<td></td>
<td>- Increase opportunities for repetition and rehearsal, checking for understanding</td>
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Strategies for Individuals to cope

- It’s ok to ask for help, e.g. repetition, simpler instructions, Pair up with a friend and share the load
- Go visual - take a photo, draw a picture
- Go permanent – give it a structure – plan write it down, record it
- Slow it down – pace is important, demand time to think and make an effort to fight distractions
- 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 effective cognitive training?

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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

Demo at mycogmed.com
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Adaptively Challenging

The difficulty level will automatically adjust based on the performance of the user so that they always train at the limits of their working memory capacity.

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Variable Protocols

<table>
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<tr>
<th>#</th>
<th>Session Length</th>
<th>Days per Week</th>
<th>Number of Sessions</th>
<th>Number of Exercises per Session</th>
<th>TOTAL TIME</th>
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<tbody>
<tr>
<td>1</td>
<td>50 mins</td>
<td>5</td>
<td>25</td>
<td>8</td>
<td>5 weeks</td>
</tr>
<tr>
<td>2</td>
<td>50 mins</td>
<td>4</td>
<td>25</td>
<td>8</td>
<td>6 weeks, 1 day</td>
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<tr>
<td>3</td>
<td>50 mins</td>
<td>3</td>
<td>25</td>
<td>8</td>
<td>8 weeks, 1 day</td>
</tr>
<tr>
<td>4</td>
<td>35 mins</td>
<td>5</td>
<td>30</td>
<td>5</td>
<td>6 weeks</td>
</tr>
<tr>
<td>5</td>
<td>35 mins</td>
<td>4</td>
<td>30</td>
<td>5</td>
<td>7 weeks, 2 days</td>
</tr>
<tr>
<td>6</td>
<td>35 mins</td>
<td>3</td>
<td>30</td>
<td>5</td>
<td>10 weeks</td>
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<tr>
<td>7</td>
<td>25 mins</td>
<td>5</td>
<td>40</td>
<td>3</td>
<td>8 weeks</td>
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<td>8</td>
<td>25 mins</td>
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Monitoring progress: Questionnaire

- Involves racing against other robots on different tracks
- The more you win, the more options you have
- The right and left arrows control the direction of the robot; the space bar to jump
- With the extra “energy” that the child has earned from Cogmed RM, they can get extra speed
Cogmed Coaching Centre

Training Details

Cogmed Progress Indicator (CPI)

- **Protocol**
  - Shape up, Listen up, Add up tasks
  - Embedded in program
  - Math challenge (auto/manual removal)
  - CPI has cognitive load
  - Best performance out of Days 1 and 2 used as Baseline Measure
  - Occurs on 6 sessions (*occurrence depends on training protocol selected*)

- **Purpose**
  - Provides quantitative measure of training effect
  - Assess with non-trained working memory tasks
  - **Track cognitive change as it occurs**

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How is Cogmed offered in Australia/NZ?

1. On a Per User basis, through a Qualified Clinician
   (Clinical RRP is $1500)

2. On a Per Institution basis, training a set number of individuals using on-site coaches (schools and rehabilitation facilities) (prices include coach training)

Cogmed Plus

“Cogmed ‘creates an opportunity for change’ but the ultimate benefit depends on how that opportunity is used - e.g. to build literacy, social skills, lifestyle habits, resilience and so on.

The extent to which it works cannot be separated from the support, the rewards, the matching content that the school and coaching environment can provide”.

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)

Case study: “Child not progressing”

- Jack is in Kindy (Prep)
- Aged 6 years and 3 months
- Making slow progress compared to peers
- 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 report
- Classroom observation using the * CELF-4 Observational Rating Scale *, completed by the:
  - Teacher
  - Clinician, and
  - Parent
- Conduct a formal language assessment

Jack’s Working Memory index score is **77** with a percentile rank of **6**, indicating performance in the **low** range.
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.

The following was recommended to help Jack with his memory, attention, and communication difficulties:

**Memory**

In addition to Cogmed, the following practical strategies were recommended:

- 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!”
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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.

Adaptive Cognitive Training Enhances Executive Control and Visuospatial and Verbal Working Memory in Beginning Readers

Judith G. Foy and Virginia A. Mann

Abstract

This study examined whether children’s working memory could be enhanced by adaptive cognitive training (ACT) and whether training outcomes would relate to behavioral self-regulation, a measure of executive control (EC) and certain pre-reading outcomes (phoneme awareness and letter knowledge).

✓ Significantly improved near transfer (untrained VS task)
✓ Significantly improved far transfer ([tests of verbal working memory and behavioral self regulation]

◊ no direct effects on measures of pre-reading skill. Findings suggest that ACT may indirectly help children at risk for later reading problems to benefit from instruction opportunities by developing self-regulation and memory skills.

Working Memory Training is Associated with Long Term Attainments in Math and Reading

Stina Söderqvist* and Sissela Bergman Nutley

Followed the academic performance of two age-matched groups during 2 years. As part of the curriculum in grade 4 (age 9–10), all students in one classroom (n = 20) completed Cogmed Working Memory Training (CWMT) whereas children in the other classroom (n = 22) received education as usual.

Performance on nationally standardized tests in math and reading was used as outcome measures at baseline and two years later. At baseline both classes were normal/high performing according to national standards.

At grade 6, reading had improved to a significantly greater extent for the training group compared to the control group (medium effect size, Cohen’s d = 0.66, p = 0.045). For math performance the same pattern was observed with a medium effect size (Cohen’s d = 0.58) reaching statistical trend levels (p = 0.091). Moreover, the academic attainments were found to correlate with the degree of improvements during training (p < 0.053).

>> Results suggest improved working memory boosts student’s capacity to learn
Improvements from Cogmed Working Memory Training

Double-blind placebo-controlled studies (i.e. RCT’s) published in peer-reviewed journals, show that Cogmed training improves:

✓ Working Memory
✓ Attention

80+ studies published on Cogmed to date as well as reviews, meta-analysis (Spencer-Smith & Klingberg, 2015) and book chapters, including MANY studies by fully independent research teams. More than 90 ongoing and planned studies. See www.cogmed.com.au/research for links to research hub.

What strategies will you use to manage a difficult new text?

- Highlighting words you don’t know
- Have a dictionary handy
- Summarise at each paragraph before continuing
- Draw a mind map
Learn more about Cogmed

Try the demonstration: http://mycogmed.com
“Try Out Cogmed”

Learn more about becoming a Clinical Coach

Learn about working memory and how to implement Cogmed at your school: www.cogmed.com.au/learning

Contact: Mimma Mason or Yvonne Peros at Pearson info@cogmed.com.au