Working Memory & Math: Cogmed & Dybster Calcularis
Computerized interventions used for improvement

December 6th 2017

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Agenda
• Why is working memory training salient?
• What is working memory?
• How would you define and describe it?
• How does it differ from long term memory & short term memory?
• Are there interventions for WM that work? Cogmed & Dybster Calcularis
• How do you effectively implement them?
Working Memory: What does it consist of?

- How does it differ from other types of memory?
- Is it the same as Attention? or Simple Recall?
- Is it the same as Long-Term Memory?
- Is it the same as Short-Term Memory?

Structure of Long-Term Memory

- Long-term memory
  - Declarative memory
    - Semantic memory
      - General understanding
      - Factual knowledge (Education)
  - Episodic memory
  - Procedural memory
    - Practical routines
    - Personal life (temporally and spatially classification)
    - Public life (important events, celebrations)

- Non-declarative memory

Procedural memory

- Playing the guitar
- Painting a picture
- Riding a bicycle
What is working memory? How does it differ from other types of memory?

**Working Memory - Definition**

- WM requires the manipulation of stimuli - not just the repetition of visual or auditory input.
- It may involve re-ordering, or regrouping or applying information learned in order to problems solve.

**Example from SAT test in UK**

How would you solve this problem?

2/5 x 140 = ?

e.g. 140 divided by 5 = ?
140 divided by 10 = ?
14 x 2 = 28
28 x 2 = 56
Is there any research on WM deficits?

**WM deficits correlate with Reading Comprehension Problems: Meta-analysis.**
(Carretti, et al., 2009)

Good comprehenders vs poor comprehenders:
...memory tasks that are demanding in terms of attentional control and that require verbal information processing are best at distinguishing between these two groups.
...suggesting that both domain-specific factors as well as general factors of working memory contribute to reading comprehension performance.”

**Visual Spatial (VS) WM & VS Short Term memory PREDICT Math Achievement.**
(Bull et al, 2008)

For 4 year old children WM & ST memory along with EF (executive functioning) predicted 1st grade and 3rd grade achievement.

**BETTER DIGIT SPAN (verbal working memory) & EF skills provided an immediate head start in math and reading that was maintained through the first 3 years of school.**

Visual spatial working memory and visual spatial short term memory predicted math achievement at each time point.

EF (executive functioning) skills predicted learning in general.
Growth in WM predicts better math problem solving 
(Swanson, et. al., 2008)

n=353 at risk elementary school children 1st-3rd grades. 
Assessed children at risk for serious math problems. 
Is growth in working memory an important predictor of 
children’s problem solving in math? YES.

Growth in WM is an important predictor of children’s problem solving 
beyond the contribution of reading, calculation skills, and individual differences in phonological 
processing, inhibition, and processing speed.

How does WM of those with ADHD affect learning?

Poorer WM = more errors, slower learning, no 
automaticity. (Huang-Pollock & Karalunas, 2010)

When a task has a 
low WM demand 
Children with ADHD 
still make more 
errors.

When a task has a 
high WM demand 
Children with ADHD 
can’t get to 
automaticity.

Result of these struggles: A distinct trajectory of 
less academic achievement.

The Lack of Development of Working Memory (WM) in 
ADHD. 
How VSWM became the target for Cogmed.

Working Memory
data from Poon and 
Scarborough (2010) 
working memory of children with ADHD 
and healthy controls.
Is there any research from the standardization of the WISC-V on working memory? How did children with LD do on the WISC-V?

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Learning Disabled - Reading

Table 5.20: Mean Performance of Subjects Learning Disability - Reading and Matched Control Groups

<table>
<thead>
<tr>
<th>Reading/Disability</th>
<th>Specific Learning Disability</th>
<th>Matched Control</th>
<th>Group Mean Comparison</th>
<th>Standard Difference</th>
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<tbody>
<tr>
<td>VCI</td>
<td>88.9</td>
<td>80.1</td>
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<td>VSI</td>
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Math - LD

Table 5.21: Mean Performance of Subjects Learning Disability Mathematics and Matched Control Groups

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Working memory impacts your daily life

Working memory is used for:
- Concentration
- Problem solving
- Remembering tasks
- Organization

Multiple failure points in the life of the working memory deprived

Age: School > Higher Education > Career

Challenges: Fitting in, Learning to read, Getting into college, Graduating, Promotion, Achieving goals

Working memory acts on underlying levels

Skill/behavior:
- Reading comprehension
- Math skills
- Language development
- On-task behavior

Influences:
- Rate of learning
- Manipulating information
- Remembering directions
- Concentration

Executive function:
- Working memory
- Planning
- Attention
- Tasks
- Organizing
Working Memory and Academic Achievement

Key facts about the correlation between working memory and learning.

- Linked to key learning outcomes in literacy, numeracy and beyond
- General learning difficulties (i.e. forgetting instructions, place keeping errors, missing key information.
- Working memory at 5 years old is a better predictor of academic success than IQ
- Linked to a number of emotional and behavioral problems
- Reading comprehension and math difficulties

Working Memory and Learning

- Poor WM affects about 15% of children. (Gathercole & Alloway, 2008).
- Children with poor WM make poor academic progress. Over 80% of children with poor WM struggle with math and reading (Gathercole & Alloway, 2008).
- WM is important for successful learning in individual classroom activities (Gathercole & Alloway, 2008)
- WM ability predicted attainment on national assessments at 7, 11, 14 years of age (Gathercole et al., 2004; St Clair Thompson & Gathercole, 2006).
- People of lower WM capacity mind-wander more than people of higher WM capacity when activities require considerable effort and focused concentration (Kane et al. 2007).

Effort / Demand

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Identifying 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
- Struggles with completing a task
- Difficulties when planning and organizing something with multiple steps
- Often seems restless and on the go
- Loses belongings frequently

Working Memory in the Classroom

Teacher Descriptions of Students:
- Unfocused
- Not listening to instructions
- Daydreaming
- Hyperactive or Impulsive
- Unmotivated
- Procrastination
- Difficulty remembering reading passages
- Inability to memorize facts
- Inability to break down word problems
- Inability to write coherently
- Lack of participation
- Forgetful

Classroom Strategies

Educational Strategies
- Breaking down information or instructions
- Provide memory aids and visual supports
- Playing visual or auditory memory games
- Repetition and Review
Computerized Interventions

Interventions used to support students
Computer based support

**Cogmed**
Computer based intervention for working memory
Provides exercises that working memory and related functions

**Dybuster Calcularis**
Computer based intervention for dyscalculia
Software designed to target math

What is Cogmed?
An adaptive, online training program proven to increase working memory – which underlies Attention, Behavior, and the Capacity to learn

- Working memory is linked to key learning outcomes in literacy, numeracy and beyond
  - Over 80% of students who complete the Cogmed training see improvement of over 30% in working memory
  - Wide range of applicability - ADHD, Dyslexia, ELL, Title I, "504 accommodation" students
  - Over 60 published studies on Cogmed benefits
Cogmed Training Outcomes

Cogmed is the most researched method for strengthening Working Memory. Has been demonstrated to improve:

- Attention
- Behavior
- Capacity to learn “Cogmed ABCs”

What makes Cogmed work?

1. **Scientific** – designed by leading neuroscientists
2. **Adaptive** – in real time
3. **Intensive** – hard work
4. **Sustained** – consecutive training
5. **Supported** – your coach will be there
6. **Targeted** – WM only

Three programs for Cogmed training

- Cogmed JM: preschoolers
- Cogmed RM: school-age children
- Cogmed QM: adults

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

Training done at school – Mac, PC, IPAD or Android
Supported by a coach/teacher from the school
Choose protocol appropriate for your student – length of time and number of days per week
The results tracked online in the Cogmed Coaching Center

Cogmed is a highly structured, supportive process

2. Start-up session
3. Training and Coaching
4. Wrap-up session
5. Follow-Up Session (Optional)

For more information go to http://cogmed.com/

Track the students with detailed reporting

Reporting Features
- Trends Reporting
  Gives coaches the opportunity to look at consolidated data from multiple trainings on three levels:
  - Compliance
  - Motivation
  - Validity
- Individual Reporting
  Coaches have the option to review individual performance data and training results for each student and print out a progress report for that student.
Track the students with detailed reporting

Key research findings for Cogmed

1. Working memory is key to attention, executive function
2. Working memory can be improved by training, using right tool/protocol
3. Working memory can be improved at all age levels
4. The improvement can be tracked by on three levels: fMRI/PET, neuropsych testing, and by rating scales
5. Improved working memory generalizes to behavioral improvement
6. The behavioral improvement is sustained
7. Training effects are pronounced in populations with a WM constraint, effects not limited to ADHD

Are there programs for children with math weaknesses?
Individuals with Disabilities Education Act (2004) Specific Learning Disability

... a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, that may manifest itself in an imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculations, ...

§ 300.8

What is Dyscalculia (vs. Math LD)?

• Medical/Clinical term for the “condition”
• Term not often used in American Public Schools
• Research has lagged behind reading disability, but more recently has been catching up:
  • Most research is from the medical/clinical community, thus the term usage

What is Dyscalculia Continued?

• Affects approximately 6% of population
• Brain-Based Condition
  • Evidence showing poor communication between brain hemispheres (Integration of multiple skills)
  • Difficulty making sense of numbers and math concepts (Often can’t grasp basic number concepts).
  • Children may know what to do in math class but don’t understand why they’re doing it.
  • Less developed mental number line leads to a reduced number sense
  • Poor “automaticity”
  • The brain areas that specialize in processing of numbers for children without difficulties are delayed in their development by 4 to 6 years in children with difficulties

Psychological strain as kids

Examples of Difficulties from Everyday Life

Something costs $19.90 - Is a $20 bill enough to pay?

Swapping -

Error patterns –

\[
\begin{align*}
13 + 15 &= 10 \quad \text{//} \quad 13 + 15 = 46 \\
1 \times 3 \times 5 &= 30
\end{align*}
\]


Link to Daily Living

• People with dyscalculia:
  • Have difficulty functioning in daily life skills (paying bills, getting correct change)
  • Earn less and spend less money
  • Fall ill more often
  • Are more often in conflict with the law
  • Need more assistance at school
  • May be more anxious than others


Challenges for Schools

• Helping children with difficulties:
  • Hardly any efficient material
  • Little time of professionals
  • No means to train independently

• "Practice makes Permanent...not necessarily Perfect":
  • Math skills are automated, as such:
    • Automation requires practice (like a piano artist)
    • But: Regular training hard to organize

  • Less progress than all hope for
  • Calculators: Efficient, anytime/anywhere, on one’s own

Differentiate from Related Conditions

- Math Anxiety
- ADHD
- Dyslexia


Math Anxiety

- Children may become so worried about doing math that fear and nervousness can lead to poor performance on math tests.
- Anxiety can lead to math “performance” problems, not typically “understanding” problem.
- Some children may have both math anxiety and dyscalculia.
- Poor performance and underlying disability in the presence of increased expectations often lead to academic related emotional conditions, such as anxiety.
- Anxiety also inhibits the neurotransmission and hence reduces the capacity for learning.

www.understood.org (8/17/16).

Dyslexia

... by neurobiological in origin... characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities... typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction...

- Children often receive diagnoses of both dyslexia and dyscalculia.
- Approximately 43–65 percent of children with math disabilities also have reading disabilities.

ADHD

- Some children exhibit characteristics of both dyscalculia and ADHD.
- Often diagnosed with both.
- However, care needs to be taken when analyzing math errors in these cases.
- These children exhibit impulse dyscontrol and inattention in math, often better explaining their errors.
- Best practice is to evaluate math after ADHD symptoms are controlled.

What is Dybuster Calcularis

- A mathematical learning software that helps make the process of learning math more efficient for students.
- Uses the latest neuroscience and advanced data analytics to adapt to the capabilities and speed of each individual learner.
- Supports learning development in exactly the areas where difficulties lie and provides educators with real-time data as to the progress their students are making.
- Addresses the foundational skills included in all state and common core standards that are the necessary for a successful math learning experience.

Calcularis Features and Benefits

- Personalization: Dybuster Calcularis uses advanced data analytics to adapt to the capabilities and speed of each individual user and supports children’s learning development in exactly the areas where their difficulties lie.
- Game Based Learning: The game-based courses help make learning fun. As a reward, users can purchase animals for a virtual zoo, increasing their motivation and enhancing their enjoyment in learning.
- Independent Training: Children work independently at a computer at school or home. While it’s important for adults to support and encourage learners, the software manages the training. Dybuster Calcularis indicates immediately—after each input—whether the answer given by the child is right or wrong.
- Video Tutorials: Instructional videos guide the user gently through the program and the 17 games.
Dybuster AG, a Swiss company, is the owner of Calcularis and Orthograph. Pearson Clinical Assessment, a business unit of NCS Pearson, Inc., is the authorized distributor of Calcularis and Orthograph within the United States.

Calcularis Features and Benefits Cont.

- Progress Monitoring:
  - Personal Progress: Learners can track their progress using a fun animated graph. This can increase their motivation and encourage them to celebrate the acquisition of new skills.
  - Teachers: The Dybuster Calcularis Coach program is offered to enable administrators and teachers to see which fundamental skills are being developed and trained.

Insight into Learners’ Work

- Learning times
- Progress
- Prompts and tasks
- Class overview
- Certificates and reports
- Transparent documentation

For more information go to: PearsonClinical.com/DybusterCalcularis
Thank you!

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