Cogmed’s Core Efficacy: Training Working Memory

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October, 2016
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Agenda

Cogmed’s Core Efficacy: Training Working Memory

Cogmed improves working memory.

Proof?

5 Arguments for Cogmed’s core efficacy.

Why the resistance to Cogmed?

The far transfer challenge.

Baddeley’s model of WM

Why does improved WM matter?

Limiting factors

Meta-Analysis of WM training.

Staying true to the Cogmed model.

Summary
Cogmed’s Core Efficacy: 
Training Working Memory

Cogmed is a working memory training program.  
This is 1st argument that improved working memory is the core efficacy of Cogmed.

Research has found that Cogmed is an effective approach for improving working memory, both visual spatial working memory (VSWM) and verbal working memory (VWM).

This finding is thought provoking.

Its implications are complicated and potentially far-reaching.

We believe that many professionals are still attempting to figure out how to make use of this finding while others still doubt its veracity.

Previous to the first Cogmed study in 2002 working memory (WM) was not considered malleable.  
So what?

**Cogmed’s 2 most supported claims.**

1) Cogmed leads to **sustained improvements in working memory, from childhood to adulthood** (M2, M5), as seen in
   
   a) preschoolers (6, 16, 41, 42, 61) – **5 studies**
   b) children and adolescents (1, 3, 7, 13, 18, 25-27, 33, 34, 36, 45, 50, 52, 53, 62, 64, 66, 72) – **19 studies**.
   c) adults and old adults (5, 15, 22, 28, 37, 38, 46, 47, 68, 70, 71) – **11 studies**.

A total of 35 studies support the first claim. Certainly quality of studies must be considered but typically higher quality studies come later so one would expect that quantity may be related to quality.

The volume of research that found that Cogmed improved working memory is the 2nd argument that leads us to the conclusion that it is the core efficacy of the program.

2) Cogmed leads to sustained **improvements in attention** (M3, M5) seen in both
   
   a) subjective measures of attention (3, 11, 14, 18, 38, 31, 47, 66, 72) – **9 studies**.
   b) and objective measures of attention (5, 6, 15, 22, 25, 28, 66, 72) – **8 studies**.

**A total of 17 studies support the second claim.**

“Proof” is not as simple as one might presume?

More than a large volume of studies there are a number of well-designed Cogmed studies (e.g. healthy sample sizes, RCT’s, effect sizes are measured, etc.).

Are meta-analyses definitive? Can researchers’ biases affect even meta-analyses? (e.g. Yes, study selection, etc.).

Is evidence of brain changes convincing? Several fMRI & DTI studies are they sufficient? If we see evidence of increased connectivity and activation will that along with behavior changes convince us that Cogmed works?

Are there many cases in science in which there is a complete vacuum of dissent? Does science move forward anyway?

What is needed to show clinically or educationally meaningful change? (e.g. my client, my child…).
Putting in context the term: Evidence-based.

**Early stages of research:** Pilot studies with no controls moves on to larger sample sizes, passive controls and then to active controls to RCT’s. Then meta-analyses. *To get just one meta-analysis within a field suggests a more advanced level of development in that database.*

Does ‘**evidence-based**’ mean 100% consensus within a field? Science is quite a bit more messy than that.

When an innovation makes it through one level it typically will get even more scrutiny the longer it survives. Scrutiny intensifies it does not diminish.

**Science is not bereft of politics.** As anyone who has completed a doctoral degree knows knowledge is quite political. There are politics within academic departments and within fields of inquiry.

*It is unusual, rare and unexpected for scientific scrutiny and criticism to simply vanish from any domain of inquiry.* (Consider global warming, the relationship of vaccines and autism, etc.).

**Scrutiny often provokes more research and in turn the research answers more nuanced questions.**
35 Controlled studies, but how many RCT’s? How many meta-analyses?

How many of these studies are blinded, randomized controlled trials (RCT’s) (e.g. what most consider to be the gold standard of research)? 14.

“This has since been replicated by independent research groups worldwide in studies of high methodological rigor (blinded, randomized controlled trials) (16, 25-27, 33, 41, 50, 62, 64, 66, 68, 70, 71, 72).” (Söderqvist, & Nutley, 2016, Cogmed claims and evidence). **This is 14 RCT’s.**

Additionally 4 independent meta-analyses of WM training have also found Cogmed has improved working memory (M1, M2, M4, M5). 1 meta-analysis by co-authored by the original Cogmed investigator Klingberg (Spencer-Smith M, Klingberg T, 2015). (Söderqvist, & Nutley, 2016, Cogmed claims and evidence). **5 meta-analyses.**


**The quality of evidence finding Cogmed improved working memory is the 3rd argument supporting the contention that improved working memory is the core efficacy of Cogmed.**
Working memory training has caught on but Cogmed typically has the largest effect sizes.

“One published meta-analysis showed that improvements in WM following Cogmed were of large effect sizes \( d = 1.18 \) in verbal and \( d = 0.86 \) in visuo-spatial \( (M2) \).”

“Furthermore, in comparison with other WM training programs, the effects seen after Cogmed were larger than all other interventions. This finding has since been reproduced in a larger meta-analysis with more than 100 studies \( (M5) \). Thus, the research evidence for Cogmed has consistently demonstrated significantly improved WM.” (Cogmed Claims & Evidence – Extended Version V 4. Soderqvist & Nutley).

The size of the effect upon on working memory is the 4th argument in favor of improved working memory as the core efficacy of Cogmed.


Effect size conceptualized

Effect size (standard mean difference) = \((\text{mean of experimental group})-\text{(Mean of control group)}\) / Pooled Standard Deviation

This is reported typically as a Cohen’s d or ‘d’.

So an effect size of .3 means that the score of the average person in the intervention group was .3 standard deviations above the average person in the control group.

Similarly an effect size of .8 would mean that the average person in the intervention group would exceed the scores of 79% of the control group.

Cohen suggested one way of understanding effect size (1988):

.8 = large (8/10 of a standard deviation unit)
.5 = moderate (5/10 of a standard deviation unit)
.2 = small (2/10 of a standard deviation unit) [1]

Even a small effect size is a significant difference between groups. However, the meaning of effect size varies by context.
Effect size meaningfulness varies depending upon context. Consider some contexts.

(Coe, 2002)

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Domain</th>
<th>Effect Size</th>
<th>Source</th>
</tr>
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<tbody>
<tr>
<td>Individualized instruction</td>
<td>Achievement</td>
<td>0.10</td>
<td>Bangert, Kulik and Kulik (1983)</td>
</tr>
<tr>
<td>School-based substance abuse education</td>
<td>Substance use</td>
<td>0.12</td>
<td>Bangert-Drowns (1988)</td>
</tr>
<tr>
<td>Treatment programmes for juvenile delinquents</td>
<td>Delinquency</td>
<td>0.17</td>
<td>Lipsey (1992)</td>
</tr>
<tr>
<td>Inquiry-based vs traditional science curriculum</td>
<td>Achievement</td>
<td>0.30</td>
<td>Shymansky, Hedges and Woodworth (1990)</td>
</tr>
<tr>
<td>Therapy for test-anxiety (for anxious students)</td>
<td>Test performance</td>
<td>0.42</td>
<td>Hembree (1988)</td>
</tr>
<tr>
<td>Mainstreaming vs special education (for primary age, disabled students)</td>
<td>Achievement</td>
<td>0.44</td>
<td>Wang and Baker (1986)</td>
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<tr>
<td>Relaxation training</td>
<td>Medical symptoms</td>
<td>0.52</td>
<td>Hyman et al. (1989)</td>
</tr>
<tr>
<td>Targeted interventions for at-risk students</td>
<td>Achievement</td>
<td>0.63</td>
<td>Slavin and Madden (1989)</td>
</tr>
</tbody>
</table>

http://www.leeds.ac.uk/educol/documents/00002182.htm

“It's the Effect Size, Stupid
What effect size is and why it is important.” Online article by Robert Coe, (2002).
How long do effects last?

WM improvements have been found to be sustained from 2 to 12 months based upon 11 follow up studies (3, 7, 14, 18, 33, 36, 37, 41, 47, 61, 71) and two meta-analyses (M2, M5).”

Several studies have found that effects last from 2 to 12 months. One study found effects lasting through 2 years. (Compare this to the length of time other interventions last.)

Effects that last are the 5th argument that improved working memory is the core efficacy of Cogmed.
Substantial empirical support for the claim that Cogmed improves working memory (WM).

As can be seen here 5 arguments that improved working memory is the core efficacy of Cogmed.

1. Working memory is the target of Cogmed.
2. Volume of data that support this finding.
3. The quality of the data with 14 RCT’s and 5 meta-analyses.
4. The effect sizes of improved working memory are moderate to large.
5. The longevity of the effects from 2 to 12 months with an outer limit of up to 2 years (that has been researched).
Why is there resistance to Cogmed?

The conclusion that Cogmed results in improved working memory has evoked resistance.

Why?

Is it because previously working memory was not thought to be malleable?

Is it that many scientists are stuck in out-dated models?

Is the data is insufficient in volume or quality?

Is the mechanism of change is not clearly defined?

Is it because Cogmed is judged based upon far transfer instead of improved working memory?

*We believe a preoccupation with far transfer is a critical consideration.*

*However resistance to change and even fear cannot be completely ruled out.*
Near transfer and far transfer related to Cogmed?

**Near transfer**: Improved working memory on tasks that are independent of the originally trained tasks, but quite similar functionally to the original tasks. (Necessitates independent, empirically reliable and valid outcome measures.)

**Far transfer**: Improved application or utilization of working memory to other tasks like reading comprehension, mathematics or activities of daily living.

How working memory is measured in Cogmed studies becomes critical to establish whether there was ‘near transfer’ or not?

In other words, are the measures of working memory sufficiently independent and standardized to believe that working memory actually improved?
Far transfer introduces a multitude of factors that complicate the picture.

Consider, again, the complexity of the example of far transfer in an educational context:

“With far transfer, the two situations are interestingly different. For example, the student who has learned a basic arithmetic rule proceeds to apply it later in a variety of word problems with no cues. Or knowledge of Spanish facilitates the learning of French. Far transfer (sometimes referred to as “high-road” transfer) often requires insight or judgment not required by near transfer.” http://www.projectlearnet.org/tutorials/transfer_of_training_or_generalization.html

In the case of Cogmed far transfer might be considered to be improved reading comprehension or mathematics, but improving reading comprehension or math is a rather complicated proposition…
The Far transfer challenge.
Consider Multiple Factors: Limiting, Moderating & Facilitating?

INDIVIDUAL LIMITING FACTORS:
1. “Mindsets”: Growth-oriented vs. static mindset.
3. Behavior issues: Impulsivity, hyperactivity, defiance, etc.

Near Transfer:
Improved working memory, Sustained Attention, Following Instructions.

Facilitating Factors?
Executive Functions (EF)?

DOMAIN LIMITING FACTORS?
Domain Specific knowledge (vocabulary? Phoneme knowledge, etc.)

Domain general skills (processing speed?)

FAR TRANSFER?
Reading comprehension?
Math?
Language acquisition?

Teaching or training to address far transfer areas of interest is likely necessary.

Cogmed is not a silver bullet. It is part of the process. Possibly the beginning…

Cogmed improves working memory. How with that improved capacity be used?
Cogmed’s Core Efficacy: Improved working memory.

To understand the implications of this core finding one must understand both the definition of working memory and how it relates to other functions of memory and learning.

Striking and surprising is the role that working memory seems to play in so many clinical and educational areas of functioning.

What exactly is working memory?
Working Memory:

2 Critical components: A system for temporary storage & manipulation of information, necessary for a wide range of cognitive tasks.

To keep information in your mind for a short period of time (seconds) & use in your thinking.

Processes all stimuli we encounter - updating.

Delegates to different parts of our brain to take action – shifting.

Allows us to block out unnecessary information - Inhibition.

Keeps us updated on what’s happening – & focused on what matters.
Do you have any room left on your desk?

Working Memory: The Mental Workspace

“…working memory as a mental workspace in which products of ongoing processes can be stored and integrated during complex and demanding activities (Just & Carpenter, 1992).
Why is Working Memory Important?
The Foundation for learning.

WM: Where learning takes place
Problem solving and comprehending texts
Interface between input and output

Consider working memory: “putting memory to work”.
Why is working memory important from a student’s point of view?

Working memory is used for:

- Controlling attention
- Resisting distraction
- Organization
- Complex thinking
- Problem solving
- Remembering tasks
Distinguishing Working Memory from Short-Term Memory

Short Term Memory:

Information can be held in STM for about 7 seconds

Holding a small amount of information in the mind in an active, readily available state for a short period of time.

Rehearsal, or repeating information can extend the interval.

If information is not acted upon, it will be lost after 15 to 20 seconds

Slots where information is stored temporarily.
Working Memory vs. Short-Term Memory

WM involves active, conscious *processing and storage*

STM consists of *passive storage* & automated subconscious processes

WM *controls* STM components

STM can hold more items than you can process in WM

WM & STM operate independently of one another
Baddeley’s *Model* of Working Memory (1)

Working Memory is “a *system* for the *temporary holding* and *manipulation* of information during the performance of a range of *cognitive tasks* such as comprehension, learning, and reasoning” (Baddeley, 1986, p. 34)
Baddeley’s *Model* of Working Memory (2)
Stores and rehearses speech-based information and is necessary for the acquisition of native and second-language vocabulary.

1. Short-term phonological store: auditory memory traces subject to rapid decay: ‘inner ear’ remembering speech sounds in their temporal order.

2. Articulatory rehearsal component sometimes called the articulatory loop. Acts as the “inner voice” and repeats the series of words on a loop to prevent them from decaying.
Visuo-spatial Sketchpad

Encodes, stores, organizes, and manipulates visual images and visual-sensory information.

1. **Visual Cache**: Stores information about form & color.
2. **“Inner Scribe”**: deals with spatial and movement information. Also rehearses info. In the visual cache and transfers it to the central executive.
Central Executive

Attentional controlling system:
Maintains task activities and blocks task interference

"This month’s business meeting is the same as last month’s business meeting but with many more problems."

© Original Artist
Episodic Buffer

Links information across domains to form integrated units of visual, spatial, and verbal information with time sequencing ‘episodes’ like a movie scene.

It has links to long-term memory and semantic meaning.
Why does working memory matter?

What are the implications of a WM deficit?

In school?

In college?

At work? Especially professional work?

At home?

In leisure?

As we age?

With family? Especially the care of children? Or the elderly?
Multiple points of failure over normal development in those with poor working memory.

Age:
- 4 years: Behavior problems
- 8 years: Falling behind
- 16 years: Failure in high school
- 20 years: Cannot prioritize
- 25 years: Struggles at work
- 55 years: Dead end career path

Weakness:
- Following directions
- Attention
- Staying focused
- Self-management
- Time management
- Staying sharp

Challenge:
- Fitting in
- Learning to read
- Getting into college
- Graduating
- Promotion
- Achieving goals
Why Working Memory is so salient for ADHD. How VSWM became the target for Cogmed.

How does ADHD affect learning?

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 and learn it more slowly.

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

Result of these struggles: A distinct trajectory of less academic achievement.
Far Transfer Complications: WM correlates with reading comprehension but is not the only factor.

**Across school-age development:** Meta-analysis on reading comprehension found large correlations for overall intelligence ($r=.55$) and reading decoding ($r=.69$) while short-term/working memory was moderate ($r=.41$) as was rapid naming ($r=.35$) (Finn, 2015, dissertation).

**Struggling Adult Readers:** Meta-analysis on reading comprehension with effect sizes $>.50$ for: morphological awareness, language comprehension, fluency, oral vocabulary knowledge, real word decoding and WM (Tighe & Schatschneider, 2016).

The role WM plays varies somewhat over development and it is only one factor that correlates to reading comprehension among others.
WM and math meta-analyses show correlations but variation for ages also.

David (2012) found large effect sizes in which those with math learning difficulties had poor central executive WM and visual spatial WM, but this was accentuated in younger ages. He also found a moderate effect between phonological WM and math.

Swanson & Jerman (2006) found that average achievers outperformed children with math disabilities (MD) on: “verbal problem solving, naming speed, verbal working memory (WM), visual – spatial WM, and long-term memory (LTM).”

Again, the impact of WM varied over age.

Secondly, several factors distinguished average performers from those with math disabilities and these factors need to be considered.
WM matters: A surprising range of mental health disorders have deficits in WM accompanying them.

DISORDERS WITH WELL KNOWN WM DEFICITS: ADHD, TBI, stroke, LD, children with learning difficulties, specific language impairment.

LESS OBVIOUS DISORDERS WITH WM DEFICITS: schizophrenia, anxiety, depression, intellectual disabilities, autism/Asperger's, Parkinson's, pain disorders (including chronic pain), fetal alcohol disorder, suicidal behavior, OCD, PTSD, bipolar disorder, First episode psychosis, children with externalizing behavior problems, alcoholism, chronic opioid use, prodromal psychosis, chronic fatigue syndrome, cocaine users, multiple sclerosis.

KEY:

BOLD: Those in bold actually have meta-analyses done on using computerized cognitive training to treat the disorder.

ITALICS: Those in italics have meta-analyses related to the patient population and working memory deficits.
The structure of working memory abilities across the Adult Life Span. WM matters for normal aging.

(Hale, et al., 2011)

Another set of data points which highlights the importance of working memory.
Limiting factors: Disorder severity & level of comorbidity are factors we have found necessary to consider.

Optimize COGMED: Fidelity to the program and judicious selection of clients for the program. Also, critical is to thoughtfully frame expectations which includes consideration of several factors.

Judicious selection of clients requires careful consideration of disorder severity, comorbidity, Rx and whether other interventions are needed during or after COGMED.

Pearson has previously given rule outs of things like oppositional defiant disorder (ODD), conduct disorder (CD), anxiety, depression, photo-sensitive epilepsy, etc. However clinicians need to use their own clinical judgment about whether any particular client might be successful with COGMED.

Research has provided rather useful data to address some of these questions. In the case of ADHD, hyperactivity/impulsivity or combined type ADHD is considered a more severe disorder than inattentive type ADHD.

*We have found that mild to moderate severity of disorder, mild comorbidity facilitates far transfer. In some cases Rx may facilitate far transfer.*
Far Transfer (red) is more likely among those with mild to moderate severity, mild comorbidity & consideration of Rx. Gains in storage in WM, but not storage/manipulation: italics & underlined.

<table>
<thead>
<tr>
<th>Study</th>
<th>WM deficit</th>
<th>ADHD-I Attention problems</th>
<th>ADHD-C</th>
<th>ADHD-HI</th>
<th>Rx%</th>
<th>LD</th>
<th>ODD/CD</th>
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<tbody>
<tr>
<td>Holmes &amp; Gathercole, 2013 (trial 1)</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
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<tr>
<td>Holmes, et al., 2009</td>
<td>100%</td>
<td>NR*</td>
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<td>Bergman-Nutley &amp; Klingberg, 2014</td>
<td>100%</td>
<td>Mainly Attentive problems</td>
<td>Attentive problems/minor HI</td>
<td>Minor HI</td>
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<td>Minor</td>
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<td>NR</td>
<td>33% diag. 60% rated inatt.</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>9.5%***</td>
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<td>Dahlin, 2013 (not randomized)</td>
<td>-</td>
<td>33% diag. 60% rated inatt.</td>
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<td>NR</td>
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<td>Klingberg, et al., 2002</td>
<td>-</td>
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<td>100%?</td>
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<td>43%</td>
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<td>100%</td>
<td>0%</td>
<td>69.6%</td>
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<td>42%</td>
<td>17%</td>
<td>67%</td>
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<td>11.5%</td>
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<td>3.8%/0%</td>
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<td>-</td>
<td>34%</td>
<td>66%</td>
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<td>27%</td>
<td>NR</td>
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<td>100%</td>
<td>NR</td>
<td>98%</td>
<td>100% Severe</td>
<td>100%/0%*</td>
</tr>
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</table>
Meta-Analysis of WM training & Moderating Variables
(Schwaighofer, Fischer & Buhner, 2015)

Meta-analysis to examine near and far transfer effects following working memory training (not exclusive to Cogmed, but did include Cogmed studies).

CRITICAL CONCLUSION: Cogmed “stood out because it yielded a larger mean effect size than noncommercial training programs.” (Not an uncommon finding, by the way).

47 studies with 65 group comparisons found near transfer to improved short-term memory (both verbal and visual spatial) and working memory (both verbal and visual spatial) skills sustained at follow up with effect sizes ranging from $g=0.37$ to $g=0.72$ for immediate transfer and $g=0.22$ to $g=0.78$ for long-term transfer. These are significant findings ranging from the small to moderate level.

Several moderators had an influence on transfer effects.
Far transfer effects to other cognitive skills were significant, but small: nonverbal (g=0.14) and verbal (g=0.16) and not sustained at follow up. (Smaller far transfer effect sizes – not uncommon).

Some would consider smaller transfer effects as ‘self-evident’ since it is ‘far transfer’.

Others are dismissive of WM training programs because of smaller, but significant effects in far transfer.

We contest this dismissal in that Cogmed improves the target of WM which results in what we consider to be improved ‘learning capacity’.

What will you do with greater learning capacity?
Near & Far Transfer Effects Meta-Analysis

(Schwaighofer, et al., 2015)

NEAR TRANSFER:
No (k) Effect Sizes (g)
Verbal STM (short-term/long-term) 32/9 0.37***/0.22*
Visuospatial STM (short-term/long-term) 25/7 0.72***/0.78***
Verbal WM (short-term/long-term -LT) 42/11 0.55***/0.35*
Visuospatial WM (short-term/long-term) 19/6 0.63***/0.41*

FAR TRANSFER:
Nonverbal ability (short-term/long-term) 45/11 0.14*/0.02
Verbal ability (short-term/long-term) 29/5 0.16**/0.26
Word decoding (short-term/long-term) 14/5 0.08/0.21
Mathematical abilities (short-term/LT) 15/8 0.09/0.08

Note. STM = short-term memory; WM = working memory.
*p < .05. **p < .01. ***p < .001.

Nonsignificant findings in word decoding & mathematical abilities.
Small significant findings in nonverbal ability & verbal ability.
Note slightly larger differences in visuospatial areas than in verbal areas.
# Moderator Variables found to show significance.
*(Schwaighofer, Fischer & Buhner, 2015)*

<table>
<thead>
<tr>
<th>Moderator</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training dose</td>
<td>Total amount of training (in hours)</td>
</tr>
<tr>
<td></td>
<td><strong>Larger dose larger effect.</strong></td>
</tr>
<tr>
<td></td>
<td><em>(Cogmed, even using the variable protocol, tends to be viewed as a larger dose.)</em></td>
</tr>
<tr>
<td>Location</td>
<td>Location of training: Training in laboratory vs. training in school vs. Training at home</td>
</tr>
<tr>
<td>Supervision</td>
<td>If training is monitored by a person (e.g., experimenter) or if a person is just present or if no person is present</td>
</tr>
<tr>
<td></td>
<td>Supervision vs. mere presence vs. no presence</td>
</tr>
<tr>
<td>Session duration</td>
<td>Duration of single training sessions (in minutes)</td>
</tr>
<tr>
<td></td>
<td><strong>Longer sessions larger effect.</strong></td>
</tr>
</tbody>
</table>

**Notably absent of significant effects:** frequency of training per week, modality and instructional support.
## Significant Moderator Variables

(Schwaighofer, Fischer & Buhner, 2015)

<table>
<thead>
<tr>
<th>Moderator variable:</th>
<th>Area of Effect</th>
<th>Effect Size:</th>
<th>Significance:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training Dose</td>
<td>Visuospatial STM</td>
<td>.30</td>
<td>p&lt;.01</td>
</tr>
<tr>
<td>Location (home&gt;school)</td>
<td>Visuospatial STM</td>
<td>.24</td>
<td>p&lt;.05</td>
</tr>
<tr>
<td>Location (school&gt;lab)</td>
<td>Verbal WM</td>
<td>.19</td>
<td>p&lt;.01</td>
</tr>
<tr>
<td>Location (lab&gt;school)</td>
<td>Nonverbal Ability</td>
<td>.20</td>
<td>p&lt;.01</td>
</tr>
<tr>
<td>Supervision</td>
<td>Verbal WM</td>
<td>.17</td>
<td>p&lt;.01</td>
</tr>
<tr>
<td>Supervision</td>
<td>Visuospatial WM</td>
<td>.16</td>
<td>p&lt;.05</td>
</tr>
<tr>
<td>Session Duration</td>
<td>Verbal STM</td>
<td>.10</td>
<td>p&lt;.05</td>
</tr>
</tbody>
</table>
**Supervision**: If training is monitored by a person (e.g., experimenter) or if a person is just present or if no person is present.

What we call the ‘training aid’ is important in terms of transfer effects for both visuospatial WM ($g=0.16, p<0.05$), and verbal WM ($g=0.17, p<0.01$).

Supervised training was distinguished from someone being “merely present”. However, the difference was not significant after Bonferroni correction. Yet, the investigators considered their hypothesis partially supported.

Arguably, functioning as a training aid as described in Cogmed training is important and possibly significantly so.
“Titrating or dosing Cogmed”? Integrating the Meta-Analysis data with The Variable Protocol

The variable protocol adjusts frequency and duration of training.

The meta-analysis shows frequency of training can vary and not significantly reduce effects.

*Session duration* did have a significant effect on verbal STM with an effect size of .10 but it is not clear if there is a ‘cut-off’ in terms of “training dose” or “length of training sessions”.

Cogmed “training dose” or overall amount of training is roughly similar across the different protocols because as one shortens the length or frequency of training the number of weeks extends.

This leaves the issue of “length of training sessions” for consideration in the Variable protocol data.
### Variable Protocols (Cogmed RM & Cogmed QM)

<table>
<thead>
<tr>
<th>Duration</th>
<th>25 min. per session*</th>
<th>35 min. per session*</th>
<th>50 min. per session*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days/Weeks</td>
<td>5 days per week for 8 weeks</td>
<td>5 days per week for 6 weeks</td>
<td>5 days per week for 5 weeks**</td>
</tr>
<tr>
<td>Days/Weeks</td>
<td>4 days per week for 10 weeks</td>
<td>4 days per week for 8 weeks</td>
<td>4 days per week for 7 weeks</td>
</tr>
<tr>
<td>Days/Weeks</td>
<td>×</td>
<td>3 days per week for 10 weeks</td>
<td>3 days per week for 9 weeks</td>
</tr>
</tbody>
</table>

* Indicates total training time including breaks
** Standard protocol supported by published peer-reviewed research
Staying true to the Cogmed Model.

Effective work by the training aide and the coach matter throughout Cogmed.

The training aide needs to be engaged in monitoring and observing training.

Revise reinforcement if it is not working. Deliver daily or weekly.

Coaching is specific and behavioral. Coaching should be over the phone or face to face.

Consider severity of disorder, comorbidity, Rx and how to balance these issues properly with the variable protocol.

Optimizing coaching by adding your version of Cogmed Plus.
Cogmed: Beginning of change? Transfer increased linearly with amount of training time & correlated with improvement on trained tasks. WM, FI & Math Improved (Bergman-Nutley & Klingberg, 2014)

Changes register at about or more weeks into training.

As such coach support is essential.

Improve more within the program and get greater transfer.
How much Cogmed? Transfer increased linearly with amount of training time & correlated with improvement on trained tasks. WM, FI & Math Improved (Bergman-Nutley & Klingberg, 2014)

**T5-T1 showed the biggest difference between groups seen here:**

![Fig. 2 Standardized change (T5 − T1)/SDxT for the two groups](image_url)

Learning how to learn. Cogmed requires hard work over a sustained period of time.

This can model what it takes to master other skills. Skills like learning a language or playing an instrument…
Implications of Cogmed’s core efficacy of improving working memory? Cautious optimism.

A surprising number of areas of functioning are correlated with working memory.

**Excitement?** Greater working memory capacity is a key to many areas of learning. WM is relevant to normal aging, several mental health diagnoses, reading and math achievement, etc.

**Caution:** Far transfer is a challenge. Several factors mediate and limit far transfer:

- Domain general abilities (IQ, processing speed, etc.) and domain specific skills (e.g. vocabulary, phonological awareness, grammatical knowledge, etc.) as well as developmental and individual factors, etc.

=Cautious Optimism. While the potential of greater working memory capacity is very exciting. The factors limiting and mediating far transfer are sobering and merit caution in making claims. Furthermore, research evidence is very complicated to digest.

*Patience and caution are warranted as is planning to address potential limiting factors.*
Summary of key concepts & ideas:

• Cogmed’s target: Improve WM. Cogmed consistently delivers on this promise.

• 5 Arguments for improved working memory as the core efficacy of Cogmed:
  1. Working memory is the target of Cogmed.
  2. Volume of data that support this finding.
  3. The quality of the data with 14 RCT’s and 5 meta-analyses.
  4. The effect sizes of improved working memory are moderate to large.
  5. The longevity of the effects from 2 to 12 months.

• The variation of measures used to assess WM also suggest Cogmed improves it. Cautious optimism warranted.

• Inhibiting factors like severity of disorder, comorbidity & Rx should be considered.

• Training dose, session duration, supervision and location mediate Cogmed effects.

• Meta-analysis of WM training programs generally find larger effect sizes for near transfer than far transfer.

• Consideration of the variable protocol may be important.

• Stay true to the Cogmed coaching model.

• For far transfer complement Cogmed with domain specific education/training: Cogmed Plus.
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